New Orleans Energy Smart
Technical Reference Manual: Version 4.0

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ADM

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A.Introduction

ADM Associates, Inc. (ADM) is contracted as the Third-Party Evaluator (TPE) for New Orleans Energy Smart Programs administered by Entergy New Orleans (ENO).

This Technical Reference Manual (TRM) provides Unit Energy Savings (UES, or “deemed savings”) estimates of kWh (energy savings) and kW (demand reductions) for the Entergy New Orleans Energy Smart Programs. The selection of measures for inclusion in this TRM was based on:

1. Historical implementation rates of measures;
2. Identification of measures in other programs that may warrant inclusion in Energy Smart; and
3. An assessment of whether a measure is an appropriate candidate for deemed savings or if it warrants custom analysis. Some viable measures (such as HVAC variable frequency drives, or VFDs) have been excluded from this TRM as they are more appropriate for custom analysis.

A.1. Additional Sections and Updates Between TRM 3.0 and TRM 4.0

This version of the TRM expands upon the New Orleans TRM 3.0 by adding sections for new measure offerings through the Energy Smart Program, refinements of some existing sections and the development of EM&V protocols for evaluating New Construction and Retrocomissioning Energy Smart Programs. A list of these changes with a brief description of each follows below:

A.1.1. New Measures

A.1.1.1. Residential

A.1.1.1.1. ENEGRY STAR® Freezers

This measure is for the purchase a freezer meeting the efficiency specifications of ENERGY STAR® is installed in place of a model meeting the federal standard (NAECA). An ENERGY STAR® freezer must be at least 10 percent more efficient than the minimum federal government standard.

A.1.1.1.2. ENEGRY STAR® Air Purifiers

This measure involves the installation of an ENERGY STAR® certified room air purifier. An air purifier, also known as an air cleaner, is defined as a portable electric appliance that removes dust and fine particles from indoor air.

A.1.1.1.3. Thermostatic Restrictor Valves on Showerheads

This measure consists of installing a thermostatic restrictor valve (TRV) between the existing shower arm and showerhead. The valve will reduce behavioral water waste by restricting water flow when the water reaches a set temperature (generally 95˚F).

Restricting the flow when the water reaches the temperature set point, reduces the amount of water that goes down the drain prior to the user entering the shower.

A.1.1.1.4. Tub Spout Diverters and Thermostatic Restrictor Valves on Showerheads

This measure consists of replacing existing tub spouts and shower heads with an automatically diverting tub spout and showerhead system with a thermostatic restrictor valve (TRV) between the existing shower arm and showerhead. When the water temperature reaches a set point (generally 95˚F), the thermostatic restrictor valve will engage the anti-leak diverter. The water will divert from the spout to a showerhead with a closed valve, which prevents the hot water from flowing down the drain prior to use.

A.1.1.2. Commercial

A.1.1.2.1. Bi-Level Parking Garage Lighting

Automated bi-level lighting fixture with motion sensors installed in a parking garage. The fixture provides lower levels of lighting during unoccupied periods. This measure covers savings from operational changes. Savings are fixture operation only. Retrofit savings from fixture replacement should be calculated using section D.6.1 Commercial Lighting Efficiency.

A.1.1.2.2. LED Refrigerated Case Lighting

This measure relates to the installation of LED lamps with and without motion sensors in vertical display refrigerators, coolers, and freezers replacing T8 or T12 linear fluorescent lamp technology. LED lamps should be systems intended for this application. LED lamps not only provide the same light output with lower connected wattages, but also produce less waste heat which decreases the cooling load on the refrigeration system and energy needed by the refrigerator compressor. Additional savings can be achieved from the installation of a motion sensor which automatically dims the lighting system when the space is unoccupied. Retrofit projects must completely remove the existing fluorescent fixture end connectors and ballasts to qualify, though wiring may be reused. Eligible fixtures include new, replacement, and retrofit. Savings and assumptions are based on a per door basis.

A.1.2. Measure Revisions

A.1.2.1.1. Deemed Net-To-Gross Ratios (NTGR) based on primary data collection

A.1.2.1.1.1. Description

To estimate net savings[1] during Entergy New Orleans program years five through nine, the Third Party Evaluator (TPE) and implementation teams conducted participant surveys

[1] The program net savings are equal to gross savings, less savings associated with free ridership, plus participant spillover savings.

and used responses to estimate program and measure-level free ridership, spillover and to calculate the overall net energy impacts of the program.

Program-level free ridership was estimated by calculating free ridership scores for major and direct install measures, weighted by the participants' gross energy savings and demand reductions. The major and direct install measure free ridership ratios were used to factor the program verified gross savings for the two measure types to estimate free ridership. Spillover (free drivership) ratios were developed by dividing the total energy savings and demand reductions resulting from spillover measures by the total gross energy savings and demand reductions for the sample of survey respondents.

In addition to free ridership and spillover questions, in-service rate (ISR) data was collected for items acquired through residential energy kits[2].

The results of these surveys were combined to develop robust net-to-gross-ratio (NTGR) estimates and in-service rates (ISR) based on primary data collection for common measures. In service rates vary considerably by delivery method and the New Orleans TRM does not contain in-service rates for mailer kit delivery. The primary data from these surveys establishes robust estimates of in-service rates for items commonly distributed to Energy Smart participants through this delivery mechanism.

Measure-specific NTGR and ISRs appear in applicable chapters and are summarized below.

A.1.2.1.1.1. Data

During program years six through nine, the TPE completed NTG surveys for a total of 578 major measures and 169 direct install measures, as well as 221 energy kits which were mailed to participants. This information was supplemented with self-reported data from 4,394 home energy kits which were distributed through the School Kits and Education program.

Table A-1: Response Count by Measure Type and Delivery Mechanism

Measure Type	*Count of Surveys Used*
Major Measure	578
Direct Install	169
Home Energy Kits	221
School Kits	4,394
Commercial Lighting	118

[2] Residential energy kits were either mailed to program participants or distributed to 6th-10th graders to bring home to parents/guardians, a significantly different delivery mechanism than other direct install items. In both cases, kits contained LED lighting, faucet aerators and low flow showerheads.

A.1.2.1.1.2. Results

A.1.2.1.2. Net-to-Gross Ratios

Table A-2: Residential Major Measure NTGR

Measure	N	NTGR	TRM Section
Duct Sealing	282	95%	C.3.8
Air Sealing	78	95%	C.4.7
AC/HP Tune-up	135	82%	C.3.7
ENERGY STAR Window Air Conditioner	30	62%	C.3.2
ENERGY STAR Refrigerator	44	44%	C.1.10

Table A-3: Residential Direct Install NTGR

Measure	N	NTGR	TRM Section
LED Lighting	126[3]	62%	C.5.2, C.5.3
Advanced Power Strips	37	80%	C.1.7

Table A-4: Residential Home Energy Kit NTGR

Measure	N	NTGR	TRM Section
LED Lighting	221	65%	C.5.2, C.5.3
Faucet Aerators	221	92%	C.2.4
Low-Flow Showerheads	221	91%	C.2.5

A.1.2.1.3. In-Service Rates

Table A-5: Residential Home Energy Kit ISR

Measure	N	ISR	TRM Section
LED Lighting	4,572	71%	C.5.3[4]
Faucet Aerators	4,572	45%	C.2.4
Low-Flow Showerheads	4,572	62%	C.2.5

[3] Survey responses were also compared with the results of price-response and revenue neutral models used to measure NTG during years PY6 and PY9 respectively, and found the estimates to be comparable.

[4] Results only applicable to omni-directional LED lighting.

A.2. High Impact Measures

In this TRM, we refer to “High Impact Measures” (HIMs). Measures are classified as HIMs if they exceed a minimum of 1% of the sector-level savings for the residential or non-residential components of Energy Smart. Most HIMs have deemed savings parameters based off primary research conducted by the TPE as part of the Program Year 5 (PY5) through PY8 evaluation, measurement, and verification (EM&V) efforts. Measures that are not HIMs have savings values that are typically either direct reference to existing sources (such as ENERGY STAR®, Food Service Technology Center, the Department of Energy, or the California Database for Energy Efficient Resources (DEER)). These measures have been updated to reflect New Orleans weather where appropriate.

The HIMs are summarized in the subsections to follow.

A.2.1. Residential High Impact Measures

The following list includes all measures that produced a minimum of 1% of residential Energy Smart gross energy savings (kWh) in PY9[5].

- Lighting: 59.3%
- Duct Sealing: 29.3%
- Self-install Kits[6]: 6.2%
- Insulation: 1.9%
- Air Sealing: 1.2%

To-date, the EM&V activities have included primary research to refine savings estimates for all residential HIMs other than ceiling insulation and air sealing. The primary research informed 96.8% of Energy Smart PY9 residential savings. Smart Thermostats are targeted for primary research in PY11. Their savings in this TRM are based on pilot program results only. This limited EM&V sample size as well as pre-select a portion of Energy Smart participants. If PY11 measure participation is sufficient to conduct an expanded study, the TPE recommends revising Smart Thermostat Savings estimates to be based on dwelling square footage, possibly including additional relevant characteristics.

A.2.2. Commercial & Industrial (C&I) High Impact Measures

This following list includes all measures that produced a minimum of 1% of commercial Energy Smart savings in Program Year 8 (PY8):

- Custom: 95.1% and

[5] Not including the behavioral program.

[6] Kits include aerators, a showerhead and lighting.

- Prescriptive: 4.9%

As:

- Lighting: 72.6% and
- Non-Lighting: 27.4%

Custom measures are not included in the TRM and receive analysis unique to the facility based on the International Measurement & Verification Protocols (IPMVP). Though metering studies have not been completed for all facility types, the adjustments to New Orleans-specific projects has been significant. The primary research informed 93.8% of Energy Smart PY9 C&I savings.

A.3. New Orleans EM&V Studies

The following EM&V studies have been completed, allowing for incorporation of primary data into the TRM:

- Metering of residential air conditioning runtime, applied to AC replacement and duct sealing;
- Field assessment of average SEER for air conditioning units in duct sealing projects;
- Billing analysis to support reductions achieved from residential air conditioning tune-ups;
- Measurement of residential domestic hot water (DHW) temperature setpoints, incorporated into DHW replacements and low flow devices;
- Metering of residential lighting run-time;
- Metering of commercial lighting run-time for the following facility types:
    - K-12 Education;
    - Exterior Lighting (all commercial);
    - Food Preparation;
    - Food Sales: Non-24 Hour Supermarket;
    - Food Service: Fast Food;
    - Food Service: Sit-down Restaurant;
    - Health Care: In-Patient;
    - Lodging: Common Areas;
    - Lodging: Guest Rooms;
    - Multifamily: Common Area;
    - Religious Assembly/Worship;
    - Retail: Freestanding; and
    - Warehouse: Non-Refrigerated.

The data collected for these studies is summarized in Table A-6 below.

Table A-6: Parameters Validated with Primary Data Collection in New Orleans

Parameter	**Measures Affected**	**Value**	**Sample Size**
Residential Cooling Equivalent Full-load Hours	Duct Sealing, AC replacement, AC tune-up	1,637	68 homes
Residential Cooling Peak Coincidence Factor	Duct Sealing, AC replacement, AC tune-up	77%	68 homes
Residential Heating Equivalent Full-load Hours	Duct Sealing, Central AC and Heat Pump Tune-Up, Ductless Heat Pump, Ground Source Heat Pump and Heat Pump Replacement	HP: 396 ER: 600	295 homes
Lighting hours of use	CFLs, Specialty CFLs, Directional LEDs, Omnidirectional LEDs	2.38	40 homes, 355 loggers
Residential Lighting Peak Coincidence Factor	CFLs, Specialty CFLs, Directional LEDs, Omnidirectional LEDs	11.74%	40 homes, 355 loggers
Residential DHW Setpoint (deg. F)	Water Heater Replacement, Faucet Aerators, Low Flow Showerheads	122.24	37 homes
Residential AC Tune-Up Annual % Savings	AC Tune-Up	10.1%	260
Commercial Lighting Hours of Use	Commercial Lighting	Original values created for 10 facility types. See Section D.6.1.5	59 premises, 210 loggers
Commercial Lighting Peak Coincidence	Commercial Lighting	Original values created for 10 facility types. See Section D.6.1.5	59 premises, 210 loggers
Average Duct Sealing Leakage Reduction	Duct Sealing	SF: 471 MF: 443	SF: 4,939 MF: 325
Deemed Net-to-Gross Ratios	Residential: • Duct Sealing • Air Sealing • AC/HP Tune-Up • ENERGY STAR® Window AC • ENERGY STAR® Refrigerator	Varies, see section A.1.2.1.2	Varies, see section A.1.2.1.2
Deemed ISRs for Mailer kit Items	LED lighting, Faucet Aerators and Low-Flow Showerheads	LEDs: 71% Aerators: 45% Showerheads: 62%	4,572 participant responses

The following EM&V studies have been completed, allowing for incorporation of primary data into the TRM:

- Metering of residential air conditioning runtime, applied to AC replacement and duct sealing;

- Field assessment of average SEER for air conditioning units in duct sealing project; and
- Billing analysis of electric resistant heating homes to estimate equivalent full load heating hours.

Primary data collection has continued during PY7 and PY8 evaluations. After PY8 program close, the following data will be analyzed to either develop or refine important savings inputs:

- Billing data from households which installed Smart Thermostats during the PY8 program will be added to existing data from the Smart Thermostat Pilot, creating a sample size large enough to estimate kWh savings based on average annual energy use per home.
- Lighting measures constituted 52.8% of expected Residential savings in PY7. During PY8 residential M&V visits, lighting operation loggers were left in 60 homes. Their data will be used to further supplement the home annual lighting hours of operation estimate.

A.4. Incremental Costs

The TRM also provides incremental cost values for most measures. Incremental cost is defined under two possible scenarios:

- Normal replacement / New construction / Replace-on-burnout: these costs reflect the cost premium of efficient equipment compared to minimum code-compliant equipment.
- Early replacement: these costs reflect the full installed cost of the new equipment. For some measures, such as lighting controls, this is meant to capture that the measure is an add-on to existing equipment. For measures that have parameters defined for the early replacement of functioning equipment, this approach also includes the subtraction of the net present value (NPV) of the second equipment purchase.

A.5. Simulation Modeling

The savings for some weather sensitive measures were developed via simulation modeling. The model software platforms included are as follows:

- eQuest©;
- BEopt™;
- EnergyGauge USA®; and
- EnergyPlus™

A.6. Weather

Various measures in the TRM refer to Typical Meteorological Year version 3 (TMY3) weather data. This data is publicly available from the National Renewable Energy Laboratory (NREL) National Solar Radiation Database (NSRDB).

This data reflects the typical year of New Orleans weather based off historical data and is the common practice for projecting average annual savings of weather sensitive measures. Inputs from the TMY3 dataset for New Orleans included the following:

- Temperature;
- Humidity;
- Wind speed and direction;
- Cloud cover; and
- Solar radiation.

A.7. Application of Values in this TRM

It is the intent to have the values in this TRM provide parameters to stipulate ex-post gross energy savings (kWh) and demand reduction (kW) estimates. The values in this TRM do not account for free-ridership, as that is a parameter that may vary based on a program delivery mechanism (for example, the free-ridership rates for residential lighting differ significantly between retail markdown in the Consumer Products versus direct install in Green Light New Orleans). The measurement of free-ridership and the application of net-to gross is discussed in detail in Section B.3.1.4, Impact Protocol 4: Net-to-Gross Analysis.

The values in this TRM will be used to verify ex post gross energy savings (kWh) and demand reductions (kW), except when specified otherwise in an EM&V plan.

A.8. Future Studies

Each measure section includes a discussion of future studies suggested by the authors of this TRM. For many measures, no studies are recommended, and suggested updates include only updating when codes and standards affecting the specific measure change. The suggestion of future studies is focused on areas of high impact in the Energy Smart portfolio (such as duct sealing) and for the identification of potential future high impact measures (such as ductless mini-split HVAC systems and smart thermostats).

The studies detailed are suggestions on the part of the authors of the TRM and guidance and feedback on these issues is welcomed as part of the stakeholder advisory process.

The general guidelines that are provided for when a study is warranted are as follows (though occasionally subject to modification as specified in a measure-specific chapter):

- Measures should be flagged for further review if they exceed 1% of savings within the residential or non-residential portfolio. In such instances, it should be determined whether:
    I. Primary data has been collected in Energy Smart evaluations to support the deemed savings;
    II. The data is sufficiently recent to support its continued use; and
    III. If data collection to support a deemed savings revision is cost-effective or cost-feasible given the implementation and EM&V budgets for Energy Smart programs.
- Measures that are not over the high-impact threshold should be considered for impact or market assessment studies if:
    I. Stakeholders (the Council and their Advisors, ENO, implementers, interveners, the EM&V contractor, and/or other appropriate parties) conclude a measure is of strategic importance to future program implementation efforts; or
- A measure is high-impact within an important market sub-segment (such as low-income multifamily or municipal government).

B.Evaluation Protocols

B.1. Protocols Introduction

This section provides protocols for various activities related to performing Evaluation, Measurement, and Verification (EM&V) for the Energy Smart programs that Entergy New Orleans is offering to its residential, commercial, and industrial customers.

Protocols are provided as follows:

- Protocol with guidance for setting rigor level and timing of evaluations;
- Protocol for EM&V of custom measures;
- Protocol and methods for EM&V for measures that are not addressed in the Technical Reference Manual but whose savings may nonetheless be treated as prescriptive;
- Protocol with guidance for net-to-gross estimation;
- Protocol with guidance for conducting process evaluations;
- Protocol with guidance for establishing quality assurance guidelines for program implementation; and
- Protocol with guidance for future updating of TRM.

B.1.1.1. Description of the Energy Smart Program

Through Energy Smart, Entergy New Orleans offers energy efficiency solutions to help New Orleans residents and businesses save energy and money. The Energy Smart implements a comprehensive energy efficiency plan that was developed by the New Orleans City Council. Any residential, commercial or industrial Entergy New Orleans electric customer is eligible to participate. Participants in the Program are offered cash incentives for energy efficiency audits, upgrades and more.

Energy Smart offerings for residential customers include the following:

- Home Performance with ENERGY STAR® ("HPwES")
- Residential Lighting and Appliances
- Low Income Audit and Weatherization
- High Efficiency AC Tune Up Program
- Energy Smart Multifamily
- EasyCool (Residential Direct Load Control)
- School Kits & Education
- Green Light New Orleans

- Energy Smart Scorecard

The Energy Smart offerings for commercial and industrial customers include incentives for prescriptive and custom energy efficiency measures and projects. The offerings are organized according to the following categories:

- Small Commercial
- Large Commercial and Industrial
- Publicly Funded Institutions
- Retrocommissioning

The types of commercial and industrial customers eligible for the incentives include:

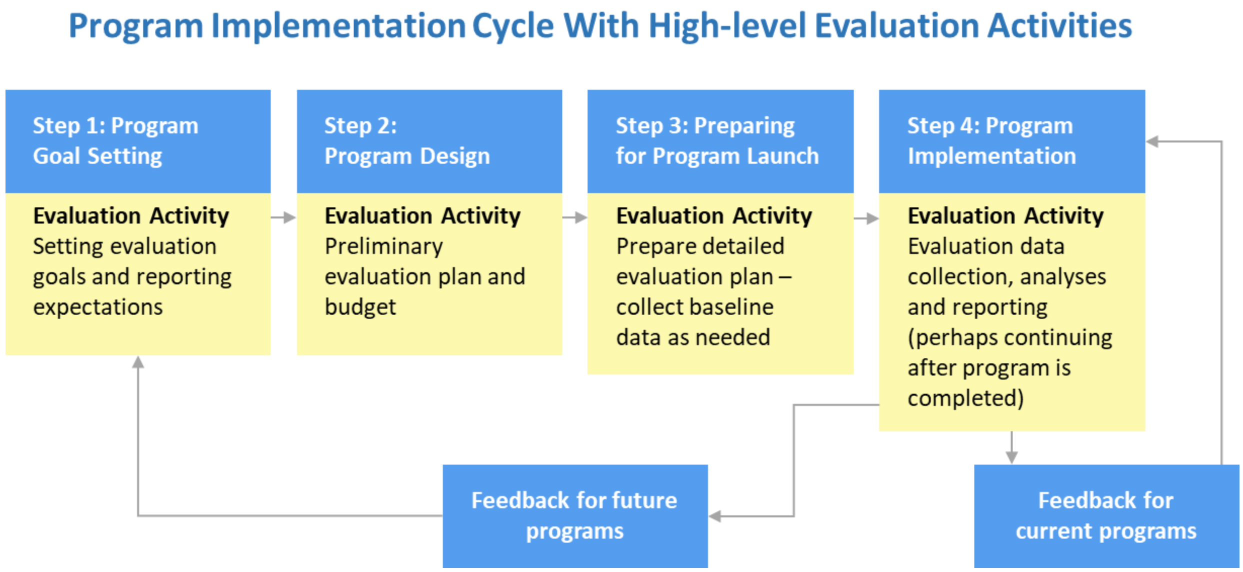
- Small businesses
- Non-profit organizations
- Large commercial facilities
- Industrial facilities
- Warehouses
- Parking lots and garages
- Office buildings
- Commercial retail buildings
- Schools
- Publicly funded buildings

B.1.1.2. Purpose of Evaluation

As defined by the American Evaluation Association, evaluation of an offering involves "assessing the strengths and weaknesses of programs, policies, personnel, products and organizations to improve their effectiveness." In the context of energy efficiency and demand response offerings, the role of future Program evaluation is two-fold:

- *Quantify Results*: Document, measure and estimate the energy and demand savings of an offering to determine how well it has achieved its goals and managed its budget.
- *Gain Understanding*: Determine why certain effects occurred (or didn't occur) and identify ways to improve and refine current and future offerings; also, to help select future offerings (NAPEE 2007).

Figure 1 provides a visual representation of the role of Program evaluation activities during the implementation life cycle of a typical energy efficiency or demand response offering. As Figure 1 shows, Program evaluation should be viewed as an ongoing process that provides information regarding changes in Program direction and adjustments to Program goals and objectives over time.



(Source: NAPEE 2007, modified for formatting)

Figure B-1: High-Level Evaluation Activities in Program Implementation Cycle

B.1.1.3. Purpose of EM&V Protocols Presented in This Volume

The protocols are intended to provide a common framework and set of reference points for conducting cost-effective evaluations of the Energy Smart Program, both energy efficiency and demand response offerings. Protocols describe the types of information that must be collected to conduct a comprehensive examination of the Program's overall effectiveness, the recommended frequency for conducting these Program evaluations, and the key metrics that must be reported during these evaluation activities.

B.1.1.4. Primary Sources Used to Prepare Protocols

Preparation of these protocols draws from leading industry references used to guide EM&V activities for energy efficiency and demand response offerings throughout the United States. Materials that were used as primary sources to prepare these protocols include the following.

- Technical Reference Manuals for Arkansas and Texas.
  - Protocols for net-to-gross analysis and for process evaluation were based on materials from the Arkansas TRM
  - Texas TRM provided materials pertaining to TRM updating.
- Steven R. Schiller, Greg Leventis, Tom Eckman, and Sean Murphy. 2017. **Guidance on Establishing and Maintaining Technical Reference Manuals for Energy Efficiency Measures**. Prepared by Lawrence Berkeley National Laboratory for the State and Local Energy Efficiency Action Network.

- Reports on evaluation frameworks that were used included the following:
  - California Public Utilities Commission. 2004 (June). **California Evaluation Framework**.
  - California Public Utilities Commission. 2006 (April). **California Energy Efficiency Evaluation Protocols: Technical, Methodological and Reporting Requirements for Evaluation Professionals** [a.k.a. TPE's Protocols].
  - DOE Office of Energy Efficiency and Renewable Energy (EERE). 2006 (February). **EERE Guide for Managing General Program Evaluation Studies**. (Referenced as EERE 2006.)
  - DOE/EPA**.** 2007 (November) **National Action Plan for Energy Efficiency (NAPEE) Action Plan and Resource Guides for Process, Impact Evaluations and Understanding Cost-Effectiveness of Energy Efficiency Programs.** (Referenced as NAPEE 2007).
  - Northeast Energy Efficiency Partnerships. 2010 (May)*.* **Regional EM&V Methods and Savings Assumptions Guidelines***.* (Referenced as NEEP EM&V Protocols).
  - NMR Group et al. 2018 (May). **Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs, Final Version**. Prepared for Pennsylvania Public Utilities Commission.
  - Steven R. Schiller and Tom Eckman. 2017 (June). **Evaluation Measurement and Verification (EM&V) Frameworks—Guidance for Energy Efficiency Portfolios Funded by Utility Customers**. Prepared by Lawrence Berkeley National Laboratory for the State and Local Energy Efficiency Action Network.
- Chapters from Uniform Methods Project, administered for DOE by National Renewable Energy Laboratory
  - Stewart, J.; Todd, A. (2017). *Chapter 17: Residential Behavior Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures*
  - Violette, Daniel M.; Rathbun, Pamela. (2017). *Chapter 21: Estimating Net Savings – Common Practices: Methods for Determining Energy-Efficiency Savings for Specific Measures*.

B.2. Evaluation Principles and Concepts

Evaluation of an energy efficiency or demand response offering is generally undertaken with two major objectives.

- A first objective is to quantify and verify savings resulting from the implementation of the offering. This is impact evaluation.
- A second objective is to collect and analyze data on offering implementation to guide decisions about future offering implementation. This is process evaluation.

Table B-1 summarizes the objectives for the two aspects of offering evaluation.

Table B-1: Comparison of Objectives for Impact and Process Evaluation

Type of Evaluation	***Objective***
Impact	***Quantify and verify savings that can be attributed to the program's activities****,* i.e., what are the results or outcomes that would not have occurred without the influence of the program. This is also called "net impacts."
Process	***Efficiency of program implementation processes***, e.g., to document the effectiveness of specific activities, what works and what does not work, where additional resources could be leveraged, participant satisfaction.

(Source: Modified from EERE 2006)

Examples of common offering evaluation objectives are:

- Assess impact of offering on customer awareness and knowledge of energy efficiency actions.
- Measure customer response to "follow-up" offering elements designed to encourage audit participants to implement recommendations.
- Examine offering awareness, delivery channels, factors that influenced participation, offering effects and customer satisfaction levels.
- Document energy efficiency actions taken by offering participants compared to actions taken by non-participants.
- Estimate energy savings accruing from participation in the offering over time; verify the reported energy savings as results of the offering.

- Determine if there have been any changes in the building characteristics of offering participants between Program years.
- Evaluate the effectiveness of Program modifications made in a specific fiscal year.
- Complete a customer segmentation analysis of the primary target population.
- Explore barriers to participation in Program activities and develop recommendations for improving the promotion and targeting of existing services, as well as new offering knowledge and services (Source: Expanded and modified from EERE 2006).

B.2.1.1. What is Impact Evaluation?

Impact evaluation is directed at measuring and verifying the changes in energy usage and demand (kWh, kW) that result from measures or projects implemented through an energy efficiency or demand response offering. There are two measures of energy savings.

- Gross energy or demand savings is the change in energy consumption or demand that results directly from actions taken by participants that are promoted by the Program ((e.g., installing energy efficient lighting) under pre-defined assumed conditions.
- Net energy or demand savings refer to the portion of gross savings that is directly attributable to the influence of the Program. This involves separating out the impacts that are a result of other influences, such as weather, energy prices, or even consumer self-motivation.

Conceptually, the relationship between gross and net savings is shown by Equations 1 and 2:

$$\text{Gross Savings Impact} = \text{Actual Energy Use}_{post} - \text{Projected Energy Use}_{pre} \quad (1)$$

$$\text{Net Savings Impact} = \text{Actual Energy Use}_{post} - \text{Projected Energy Use}_{pre} \pm \text{Adjustments} \quad (2)$$

Most program evaluations seek estimates for both gross and net energy/demand savings.

A variety of approaches can be used to quantify (estimate) gross energy savings, including statistical comparisons, engineering estimation, and modeling, metering, and billing analysis. The impact evaluation approach selected is primarily a function of the available budget, the technologies or energy end-use measures (EUMs) targeted in the program, the level of certainty of original program estimates, and the overall level of estimated savings attributable to the program (NAPEE 2007).

The net savings attributable to an offering may differ from gross savings because of free-ridership and spillover.

- Free ridership impacts are the energy savings impact attributable to energy efficiency measures that would have been installed even without the influence of a Program.
- Spillover pertains to several effects. First, participants may be influenced by the Program to invest in energy-efficient measures not included in the program. Second,

non-participants may adopt measures promoted by the Program as a direct result of the program but do so outside of the Program. One savings impact of spillover is the additional energy savings that result because non-participants purchase greater efficiency than they otherwise would have, due to differences in dealer and contractor actions or equipment availability at the time of purchase. There may also be additional energy savings from non-participants due to program marketing impact on awareness of energy-efficiency.

The goal of net savings analysis is to infer the magnitude of the free-ridership and spillover effects and hence to determine the net savings impact of an offering. Net-to-gross ratios or factors are applied to the adjusted or verified gross savings to estimate net offering savings for the Program.

There are several methods for estimation of program net-to-gross ratios. Examples include:

- Self-reporting surveys;
- Enhanced self-reporting surveys;
- Statistical analysis of billing data that compares participants' and non-participants' energy and demand patterns; and
- Statistical modeling using multi-equation discrete choice and energy consumption models of participant and non-participant participation, measure adoption, and energy consumption behavior.

Other factors might affect energy and demand levels at customer sites and need to be considered when evaluating a Program. By accounting for these factors that are beyond the control of the Program implementer or end-user, the adjustments bring energy use in the two time periods (before offering launch and after or during offering delivery) to the same set of conditions. Examples of adjustment factors include the following:

- Weather corrections;
- Changes in occupancy levels and hours;
- Production levels;
- Economic conditions;
- Energy prices;
- Changing codes/standards and common practice/changes to the baseline;
- Interactions with other offerings; and
- Changes in household or building characteristics.

These factors all affect total energy used and energy demand levels. There are a few methods for isolating the impacts of these factors to accurately attribute energy and demand reductions to the offering being evaluated.

The decision to calculate gross energy savings or net energy savings depends on the program objectives and available evaluation resources.

- Gross savings are calculated when all that is needed is an estimate of the savings for each project participating in a Program. The most common example of this is a project involving a contractor completing energy efficiency measures in a facility for the sole purpose of achieving energy savings (e.g., performance contracts).
- Net savings are calculated when one wants to know the level of savings that occurred because of the Program's influence on offering participants and non-participants.

B.2.1.2. What is Process Evaluation?

As defined in the California Evaluation Framework, a process evaluation is "a systematic assessment of an energy efficiency program for the purposes of (1) documenting program operations at the time of the examination, and (2) identifying and recommending improvements that can be made to the program to increase the program's efficiency or effectiveness for acquiring energy resources while maintaining high levels of participant satisfaction."[7] Process evaluation of a program examines the process of implementing the program and determines whether the program is operating as planned. The goal of a process evaluation is to recommend ways to improve processes to increase a program's effectiveness.

Examining program operations through a process evaluation can identify ways to make enhancements and improvements to an Offering that reduces overall Program costs, expedites Offering delivery, improves customer satisfaction, and fine-tunes Offering objectives. The evaluation can also be used to assess the effectiveness of various Offering incentives and technology rebates.

Various researchable issues that are typically addressed in a process evaluation include the following.

- Assessing the effectiveness of current operations
- Determining customer awareness of energy efficiency overall as well as awareness of the particular offerings and measures
- Characterizing customer decision-making, especially the drivers for customer participation and key motivators including energy and non-energy benefits.
- Assessing customer satisfaction with the program and key drivers
- Assessing trade ally satisfaction and key drivers
- Documenting inter-relationship between a given Offering and other Program Offerings
- Recommending areas for Program improvement

Process evaluation can be done as a one-time assessment or continuously. Performed periodically, a process evaluation of a Program can be a management tool that focuses on improving both the design and delivery of energy efficiency offerings. A process

[7] California Evaluation Framework, 2004.

evaluation can also provide feedback on ways to streamline and enhance data collection strategies for operation of a Program.

Process evaluations make use of various types of information and data. The spectrum of data collection activities for process evaluation is shown in Figure B-2. (Activities are ordered according to relative cost, from low cost to higher cost.) As can be seen, a variety of qualitative and quantitative research methods are used, beginning with a review of program materials and records, conducting in-depth interviews with program staff and implementers, and surveys with key customer and trade ally groups.

Types of Data Collection Activities for Process and Impact Evaluations

Low Cost → High Cost

Records Review	Review of program database
	Review of marketing materials
	Review of secondary materials
Literature Review	Review of secondary materials
	Review of engineering estimates and approved databases
	Review of secondary materials
Focus Groups	Small group discussions with customers trade allies, or both
In-depth interviews with key stakeholders	Program staff
	Outside consultants
	Industry representatives
Surveys	Participating customers
	Non-participating customers
	Surveys of trade allies
Site Visits	On-site observation of program operations / customers
	On-site verification of equipment operation and/or metering

(Source: Reynolds, Johnson & Cullen 2008, adapted for NOLA TRM V3.0)

Figure B-2: Types of Data Collection Activities for Impact and Process Evaluations

B.2.1.3. What are "GOOD" Evaluation Practices?

NAPEE 2007 summarizes what it considers to be the *"Best Practices in Evaluation".* These EM&V best practices are summarized below to provide further guidance for evaluation activities conducted for the Energy Smart Program.

- Incorporate an overall evaluation plan and budget into the Program plan at the beginning of Program planning;
- Adopt a more in-depth evaluation plan each Program year;
- Prioritize evaluation resources where the risks are highest. This includes focusing impact evaluation activities on the most uncertain outcomes and highest potential savings. New and pilot programs have the most uncertain outcomes, as do newer technologies;

- Allow evaluation criteria to vary across offering types to allow for education, outreach, and innovation;
- Conduct ongoing verification as part of the program process;
- Establish a program tracking system that includes necessary information for evaluation;
- Match evaluation techniques to the situation regarding evaluation costs, level of precision required, and feasibility;
- Maintain separate staff for evaluation and for program implementation. Rely on an outside review of evaluations (e.g., state utility commission), especially if the program is implemented by internal utility staff. It is important that the program evaluation is an activity conducted independently of program operations; and
- Evaluate regularly to refine offerings as needed to meet changing market conditions.

Even the best evaluation practices are based on highly refined estimates and do not provide absolute findings. The energy savings from an offering cannot be determined directly from available energy use data but must be measured against *what would have happened if the offering did not exist*. Therefore, the goal of a good EM&V protocol is to identify the best approaches for determining reasonable and defensible estimates – largely based on surveys with program participants, non-participants and other market actors – about events that would have happened in the absence of the programs.

With any evaluation, there is a level of *risk* that the estimations are inaccurate, and there are different points for an acceptable margin of error (or levels of confidence). These protocols manage the risk of inaccuracy, and minimize the margin of error, by specifying the information and data points required to properly document savings and provide the best possible estimates of energy savings.

A second major issue regarding good EM&V practices relates to the level of effort required to obtain meaningful results, while managing evaluation costs. It is important to weigh the costs associated with obtaining additional, incremental information (or developing more precise estimates of program impacts, i.e., higher certainty), with the incremental costs associated with gathering and studying additional information.

Therefore, EM&V methodologies involve a series of tradeoffs guided by answering two questions:

Q1. "What is the comparison point?

Q2. "How good is good enough?"

The answers to these questions are based on the size, scale, and scope of the overall program portfolio as it relates to the ultimate energy savings goals and objectives.

B.3. Protocols for Impact Evaluation of Measures / Projects Not Included on List of Prescriptive Measures

This chapter provides guidance and protocols pertaining to impact evaluation activities for measures and projects that are not included on the list of prescriptive measures for Energy Smart programs. Protocols are presented as follows:

- Impact Protocol 1: Timing of Impact Evaluation Activities
- Impact Protocol 2: Level of Rigor for Impact Evaluations
- Impact Protocol 3: Evaluation of Savings for Non-prescriptive Measures or Projects
  - Impact Protocol 3.1: Evaluation Approach for 100% Custom Measures
  - Impact Protocol 3.2: Impact Evaluation of Non-Prescriptive Measures Whose Savings May Be Treated as Prescriptive
  - Impact Protocol 3.3: Impact Evaluation of Information-Based Programs
- Impact Protocol 4: Net-to-Gross Analysis

B.3.1.1. Impact Protocol 1: Timing of Impact Evaluation Activities

The decision regarding the appropriate time frame for impact evaluation has two components:

- When and over what period of time the evaluation effort will take place?
- What is the level of detail or “granularity” required for the evaluation analyses?

B.3.1.1.1. When and Over What Period of Time Evaluation Effort Will Take Place.

A standard evaluation begins before program implementation begins to collect important baseline data and then continues for some time after the program is completed to analyze persistence of savings and other program elements.

The actual timing of evaluation efforts influenced by several factors, including:

- What will be the time period of analyses (i.e., how many years)?
- Will persistence of savings be determined, and if so, how?
- What is the timing for policy decisions and evaluation planning?
- What is the need for early feedback for program implementers?
- Where is the program in its life cycle?
- What are the evaluation data collection time lags?
- What are the other regulatory and/or management oversight requirements to be addressed in this evaluation?
- What information or data are needed to update specific energy and demand savings from the measure, and to quantify life estimates?

- What is the timing and format required for the reporting process? Is a single, final program report needed, or are more frequent reports required?

In general, program evaluations are conducted with a three-year plan. Process evaluations are usually conducted at the end of the first year of program operations and at the conclusion of the program period. Impact evaluations may be conducted annually or at the conclusion of Program Years 2 and 3, and generally free ridership and spillover no more frequently than once every three years provided there are sufficient data to determine energy savings estimates and adjustments and no significant changes in a program design. The timing for the EM&V activities should be specified in EM&V plans for the programs to be evaluated.

B.3.1.1.2. What Level of Detail or "Granularity" Is Required for Evaluation Analyses?

This relates to whether 15-minute, hourly, monthly, seasonal, or annual data collection and savings reporting are necessary. The granularity decision is based how the information will be used for evaluation purposes. Annual savings data provide an overview of program benefits. More detailed data are usually required for both cost-effectiveness analyses and resource planning purposes.

If demand savings are to be calculated, the choice of definition (e.g., annual average, peak summer, coincident peak, etc.) is related to time granularity. When evaluating energy or demand savings, it is important to properly define the project boundaries (i.e., what equipment, systems, or facilities will be included in the analyses). Ideally, all primary effects (the intended savings) and secondary effects (unintended positive or negative effects), and all direct (at the project site) and indirect (at other sites) will be captured in the evaluation. The decision concerns whether savings will be evaluated for specific pieces of equipment. For example, the "boundary" may include motor savings or light bulb savings estimates, the end-use system (e.g., the HVAC system or the lighting system), the entire facility, or the entire energy supply and distribution system (Modified NAPEE 2007).

The EM&V plan for each program should stipulate the confidence and precision levels necessary to provide for a robust EM&V analysis of the savings estimates and describe the sampling strategy that will be used. Sampling strategies will vary by program and across the program portfolio. The sampling strategy for a particular program should therefore be fully described in the EM&V plan for that program.

B.3.1.2. Impact Protocol 2: Level of Rigor for Impact Evaluations

Impact evaluation of gross savings can be performed under different levels of rigor, depending on available evaluation resources, uncertainty in expected savings, magnitude of expected savings, program budget, and other criteria.

The level of effort necessary to assess savings impacts is driven by the equipment type and data collection needs. The International Performance Measurement and Verification

Protocol (IPMVP) is an important and widely used guidance document that provides guidelines about the “level of effort” required to document energy efficiency savings. The IPMVP presents various M&V options, summarized in Table B-2, that help guide savings verification methods and levels of effort.

Table B-2: IPMVP M&V Options

IPMVP Option	***Measure Performance Characteristics***	***Data Required***
Option A: Engineering calculations using spot or short-term measurements and/or historical data	Constant performance	▪ Verified installation ▪ Nameplate or stipulated performance parameters ▪ Spot measurements ▪ Runtime hour measurements
Option B: Engineering calculations using metered data	Constant or variable performance	▪ Verified installation ▪ Nameplate or stipulated performance parameters ▪ End-use metered data
Option C: Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multivariate regression analysis	Variable performance	▪ Verified installation ▪ Utility metered or end-use metered data ▪ Engineering estimate of savings input into SAE model
Option D: Calibrated energy simulation / modeling; calibrated with hourly or monthly utility billing data and / or end-use metering	Variable performance	▪ Verified installation ▪ Sport measurements, runtime hour monitoring, and/or end-use metering to prepare inputs into models ▪ Utility billing records, end-use metering, or other indices to calibrate modeling

(Source: IPMVP Protocols 2010, formatted for this document)

In the California Energy Efficiency Evaluation Protocols, IPMVP M&V options are used to identify two levels of rigor for evaluation of gross energy savings.

- Basic rigor level, which is consistent with IPMVP Option A (or, in some cases, Option C).
- Enhanced rigor level, which is consistent with IPMVP Options B or D (or, in some cases, Option A).

The levels of rigor for evaluating impacts of a program can be assigned by using this correspondence between IPMVP M&V options and levels of rigor by determining which

IPMVP option should be applied to assess savings for measures or projects in a program. For example, Lawrence Berkeley National Laboratory (LBNL) maintains a webpage on its Measurement & Verification portal that allows use of interactive tools to identify the IPMVP option that is best suited to evaluating savings for a particular project. (See http://mnv.lbl.gov/interactive/ipmvp-1a-2.) This tool can be used to assign an IPMVP Option and corresponding level of rigor (basic, enhanced) to measures or projects included in a program.

The LBNL application (which is adapted from IPMVP 2012 Volume 1) identifies an appropriate M&V option based on responses to questions about the energy conservation measure/project that's being considered for evaluation. Items of information needed include the following:

- Claimed kWh savings, claimed kW reductions
- Number of different measures in a project;
- Number of installed measures;
- Descriptions of any equipment changed or of new equipment installed;
- Interactive effects between measures;
- Percentage of savings vs. baseline;

For Energy Smart programs, there are prescriptive and non-prescriptive measures. Prescriptive measures are explicitly listed as such in program materials. Non-prescriptive measures are those that are not included on the list of prescriptive measures for the Energy Smart programs. Within the set of non-prescriptive measures, a distinction can be made between 100% custom measures and measures where deemed calculation methods might be used but data need to be collected or developed to be put into the calculation algorithms.

This distinction is shown in Table B-3. For Prescriptive Measures that are included on the list of prescriptive measures, savings are deemed. (These deemed savings values are provided in the current Technical Reference Manual.) Protocols for assessing savings for Non-Prescriptive and 100% Custom Measures are discussed in Section 3.3.

Table B-3: Spectrum of Measures: 100% Prescriptive to 100% Custom

	100% Prescriptive	***Non-Prescriptive***	***100% Custom***

	Exclusive Source	*Primary Source*	*Used as a Source*	*May be used as a Source*
Deemed Calculation(s)	No	Yes	Yes	No, unless custom measure EM&V protocols are included
Deemed Variables or Factors	No	Mix of site-/project-specific and deemed data	None or minimal	None or minimal
Site- or Project-Specific Variables or Factors	No	Mix of site-/project-specific and deemed data	Exclusively or mostly	Exclusively or mostly
Deemed Savings Values	Fully deemed savings values	Partially deemed savings values	No, savings determined per deemed calculations, resulting in site-/project-specific savings values	No, savings determined per project-/measure-specific analyses and data collection, resulting in site-/project-specific savings values
EM&V Method	Deemed savings	M&V Option A	M&V Option B, C, or D	M&V Options B, C, or D (e.g., for individual commercial building projects) or control group methods (e.g., for mass market residential projects)
Source: Carroll 2013, as adapted and presented in SEE Action Guide for States: Guidance on Establishing and Maintaining Technical Reference Manuals for Energy Efficiency Measures				

B.3.1.3. Impact Protocol 3: Evaluation of Savings for Non-Prescriptive Measures or Projects

As discussed in Section 3.2, levels of rigor with which savings for non-prescriptive and 100% custom measures are assessed are determined depends on the particular methods chosen for the analysis of savings. Protocols pertaining to the choice of methods are presented in this section. In general, documentation information is used to determine (1) what methods of savings analysis to use and (2) specifications of assumptions and sources for these specifications. Protocols are provided for the following:

- 100% Custom measures
- Non-prescriptive measures that are not 100% custom
- Measures promoted through mass market programs

B.3.1.3.1. Impact Protocol 3.1: Evaluation Approach for 100% Custom Measures

Types of measures that can be considered to be 100% Custom include (1) measures or projects that site-specific but that are considered too complex or unique to be included in the list of standard measures provided in the TRM or (2) measures that may involve metered data, but that require additional assumptions to arrive at a ‘typical’ level of savings as opposed to an exact measurement.

Most measures in this category are custom measures installed in both retrofit and new construction situations in commercial and industrial (C&I) facilities. In general, these custom measures are more complex measures that require site-specific information and detailed calculations to estimate energy and demand savings. These measures do not comply with a prescriptive calculation approach or may benefit from having more detailed savings analysis.

Because custom measures are often unique, their savings are evaluated using a site-specific M&V approach, with more reliance placed on using site-specific engineering analysis and end-use metering as methods to estimate savings. The site-specific approach involves (1) selecting a representative sample of custom projects or measures that participated in a program; (2) determining the savings for each project or measure in the sample, usually by using one or more of M&V Options defined in the IPMVP; and (3) applying the results of estimating the savings for the sample projects or measures to the entire population in the program. Further information on the EM&V methods recommended for 100% Custom Measures in provided in Table B-4. Methods to determine gross savings for 100% custom measures depend on the type of measure and the end use affected (e.g., lighting, HVAC, industrial process).

Table B-4: Summary of Recommended EM&V Methods for 100% Custom Measures

Characteristic	***Approach***	***Additional Comments***
Program Tracking	Initial gross estimates of energy and demand savings and initial net impacts as applicable. Measure description with, as applicable, unit quantities, sizes/ capacities, baseline and installed efficiencies, and operating hours.	Any additional parameters that could be useful for quality control or for evaluation design, such as sampling that are described in the EM&V plan.
Recommended M&V Method	On-site inspections with partial (Option A) or complete (Options B,C,D) measurements on a census or sample of program participants. Site visits with short-term metering is the most appropriate approach for C&I Custom measures. A detailed engineering spreadsheet model can be used to capture the dynamics and interactions on an hourly basis. Data collected from Energy Management Systems (EMS) may also provide cost-effective information and should be included in EM&V plans if available.	Metering methods often include time-of-use loggers, interval kW recorders, and spot power measurements.
Alternative M&V Method	If the Custom measure involves significant HVAC equipment and/or controls, calibrated simulation modeling (Option D) offers a viable alternative for capturing measure dynamics and interaction.	Metering can be used to calibrate the model. Such metering may include whole premise interval kW recorders with some end-use metering.

(Source: Modified from the NEEP EM&V Protocols 2010)

Evaluating savings impacts for 100% custom measures or projects requires that baseline conditions be defined. The baseline reflects the conditions, including energy consumption, that were occurring before the installation of the measure. Baseline definitions consist of site-specific issues and broader, policy-oriented considerations.

- Site-specific issues include the characteristics of equipment in place before an efficiency measure is implemented as well as how and when the affected equipment or systems are operated. When defining the baseline, it is also important to consider where in the life cycle of the existing equipment or systems the new equipment was installed. The options are:

– *Early replacement* of equipment that had not reached the end of its useful life;
– *Failed equipment replacement,* with new energy efficient equipment installed; or
– *New construction*.

For each option, there are two generic approaches to defining baselines.

- *Project-Specific Baseline.* With the project-specific procedure (used with all or a sample of the projects in a program), the baseline is defined by a specific technology or practice that would have been pursued, at the site of individual projects, if the program had not been implemented. For energy efficiency programs, the baseline is established by:

  1. Assessing the existing equipment's energy consumption rate, based on measurements or historical data;
  2. Completing an inventory of pre-retrofit equipment; or
  3. Comparing to a control group's energy equipment (used where no standard exists or when the project is an "early replacement," i.e., implemented prior to equipment failure).

  The most widely accepted method, and recommended for these EM&V Protocols, is to define the baseline by determining what technologies the new equipment actually replaces. That is, the baseline is related to actual historical base year energy consumption or demand and carried forward to future years (NAPEE 2007).

- *Performance Standard Baseline.* For the Performance Standard Baseline approach, a performance standard is developed that provides an estimate of baseline energy and demand for all the projects in a program. The assumption is that any project activity will produce *additional* savings if it has a "lower" baseline than the performance standard baseline. Performance standards are sometimes referred to as "multi-project baselines" because they can be used to estimate baseline savings for multiple project activities of the same type.

  Under the performance standard procedure, baseline energy and demand are estimated by calculating an average (or better-than-average) consumption rate (or efficiency) for a blend of alternative technologies or practices. These standards are used in large-scale retrofit (early replacement) programs when the range of equipment being replaced and how it is operated cannot be individually determined. This would be the case, for example, in a residential compact fluorescent lamp (CFL) incentive program, where the types of lamps being replaced and the number of hours they operate cannot be determined for each home. Instead, studies are used to determine typical conditions. Another common use of performance standards is to define a baseline as the minimum efficiency standard for a piece of equipment as defined by a law, code, or standard industry practice. This is commonly used for new construction or equipment that replaces failed equipment (NAPEE 2007).

  This approach is especially important when it is difficult to determine baselines, such as in new construction programs since no comparison period exists. However, the concepts of project and performance standard baseline definitions can still be used in these circumstances. The industry-accepted methods of defining new construction baselines are based on:

- Specifications of buildings that would have been built or equipment installed, without the influence of the program, at the specific site of each construction project. This might be evaluated by standard practice evaluation or building plans and specifications that were prepared prior to the program being launched.
- Existing building codes and/or equipment standards; and
- Performance of equipment, buildings, etc., in a comparison group of similar program non-participants.

Because custom projects or measures are usually site-specific, site visits are generally required to collect appropriate information to analyze savings. This includes collecting information on the quantity, sizing, servicing, and scheduling for HVAC, lighting, refrigeration, motors, process and other equipment. Information may also be collected on the capabilities of control systems (e.g., whether centralized or distributed, capabilities for control monitoring, automation possibilities, and expansion possibilities).

B.3.1.3.2. Impact Protocol 3.2: Impact Evaluation of Non-Prescriptive Measures Whose Savings May Be Treated as Prescriptive

Energy Smart programs may include non-prescriptive measures that are not 100% custom measures. Savings for these measures are not deemed. However, savings can be assessed using savings calculation algorithms with stipulated and “open variables”. Examples of open variables include the following:

- Capacity of an A/C unit
- Change in connected load
- Square footage of insulation
- Hours of operation of a facility or of a specific electric end-use
- Horsepower of a fan or pump motor

Essentially, the savings calculation algorithms can be considered deemed, but the algorithms require customer-specific input for open variables to calculate the energy and demand savings. With customer-specific information used for open variables, savings values for the same measure can differ across customers.

Information on open variables can be collected from program participants or through site visits. For some open variables, a default value may have to be used when data for the open variable cannot be collected. For example, an average value can be provided that can be considered the default value for input to the algorithm and that can be used when customer-specific information is not available.

Some issues that should be considered in evaluating savings for non-prescriptive measures include the following.

- Algorithms and definitions of terms should be reviewed to verify that accepted industry standards are being used to reasonably estimate savings. This review should be used to ensure that the deemed methodologies for calculating savings are clearly defined and can be implemented practically and effectively.
- High-impact measures should be identified for review and clarifications or modifications.
- Low-impact measures with unrealistic and inaccurate savings values should be reviewed. This review can be done periodically to adjust the level of EM&V rigor based on market adoption.
- For nonresidential measures, consider establishing energy impact thresholds by measure type in the TRM, above which customer-specific data collection is required for open variables. The intent of this is to reduce the overall uncertainty of portfolio savings estimates by increasing the accuracy of project-level savings estimates for extremely high-impact measure installations.
- When to use default values for open variables in the *ex ante* and/or *ex post* savings calculations should be determined considering the savings impact and the uncertainty associated with the measure. Default values for open variables can be used if customer-specific or program-specific information is unreliable or cannot be easily obtained. The default values are appropriate for low-impact and low-uncertainty measures (e.g., lighting retrofits in a small business facility). In contrast, customer-specific values are appropriate for high-impact and high-uncertainty measures, (e.g., HVAC or lighting retrofits in universities or hospitals that have diverse facilities) and where those types of projects represent a significant share of program savings for a year.
- For key open variables where default values are provided that are based on evaluations completed in other jurisdictions or taken from industry or other associations, the literature supporting use of the particular default values should be reviewed and assessed. This may include reviewing the population from which source data were used for deriving the default values and providing recommendations as to what populations or technologies the derived default values can be applied.

Because customer-specific data for open variables are collected and used to estimate savings, there will be a variety of savings values for the same measure. Customer-specific or program-specific data for the ex ante and/or ex post savings calculations should be used for as many open variables as possible to improve the accuracy of estimated savings. Site-specific data or information should be used for measures with important variations in one or more input values (e.g. delta watts, efficiency level, equipment capacity, operating hours). Customer-specific data can come directly from measure application forms, be collected during the application process, or collected through site visits.

To guide the customer-specific data collection, measures can be grouped into various end-use categories (e.g. lighting, HVAC, motors & VFDs) and kWh savings thresholds established for each end-use category level that can be used to determine whether customer-specific information should be used for estimating ex ante and/or ex post savings. If a project involves multiple measures or types of technology that fall under the same end-use category, the savings for all those measures/technology types should be grouped together to determine if the project falls below or above a particular threshold.

B.3.1.3.3. Impact Protocol 3.3: Impact Evaluation of Savings for Information-Based Programs

Through the Energy Scorecard program, Entergy New Orleans provides information to customers that they can use to adjust their use of electricity. The protocol provided here is intended to give guidance on evaluating the impacts of this and other information-based programs that might be used to provide information to customers.

There are several evaluation approaches that can be used to determine the savings impacts of an information-based program that provides customers with information that they can use to voluntarily take actions to adjust their energy. The approaches differ in their ability to produce accurate and robust results and are therefore discussed in descending order of desirability. Because of differences in performance, Option 1 is the preferred approach. Option 2 should be used only when Option 1 is infeasible. Option 3 should only be used when both Option 1 and Option 2 are infeasible.

If available, interval meter data should be used to estimate load impacts. Where advanced metering infrastructure (AMI) data is not available for all participants, estimates based on a sample of metered homes may be used.

The three options for estimation of impacts from information-based programs are as follows.

- Option 1 uses an analysis based on an experimental design that makes appropriate use of random assignment so that the reference load is estimated using a representative control group of program participants.[8] The most common type of design satisfying this criterion is a randomized control trial (RCT), but other designs may also be used. An evaluation contractor can select a specific design, based on their professional experience.
- Option 2 uses a comparison group analysis where the loads of a group of non-participating customers that are similar to participating homes with respect to observable characteristics (e.g. electricity consumption) are used to estimate the reference load. Because there is a variety of matching techniques that are available,

[8] For discussion on the rationale of random assignment, see Stewart, J.; Todd, A. (2017). Chapter 17: Residential Behavior Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68573. http://www.nrel.gov/docs/fy17osti/68573.pdf

an evaluation contractor can choose the technique used to select the comparison group based on their professional judgment. Difference-in-differences estimators should be used in the analysis to control for any differences that may remain after matching.

- Option 3 is a 'within-subjects' analysis where the reference energy use of participating customers is estimated using data on their energy use during a period before their participation in the information-based program began.

The analysis for all three options can be accomplished through regression analysis that relates energy use to weather conditions (particularly temperature) and other variables that influence usage. Panel regression modeling is the recommended technique.[9]

B.3.1.4. Impact Protocol 4: Net-to-Gross Analysis

Net-to-Gross (NTG) analysis is directed at quantifying those savings attributable to a program. This protocol presents general definitions and methods that can be employed as part of a sound NTG analysis.

There are five approaches commonly used for determining net-to-gross ratios (NTGR).

- *Self-Reporting Surveys*: From participants and non-participants without independent verification;
- *Enhanced Self-Reporting Surveys*: Self-reporting surveys are combined with interviews and independent documentation review and analysis. They may also include analysis of market-based sales data;
- *Econometric Methods*: Statistical models are used to compare participant and non-participant energy and demand patterns. These models often include survey inputs and other non-program-related factors such as weather and energy costs (rates);
- *Deemed Net-to-Gross Ratios*: An NTGR is estimated using information available from evaluation of similar programs; and
- *Stipulated Net-to-Gross Ratios*: The stipulation of a net-to-gross ratio may be used when the expense of NTGR analysis and the uncertainty of the results are considered significant barriers (NAPEE 2007). Use of stipulated values is not recommended if they yield results that are uncertain and/or costly; instead, the protocol would support the usage of literature reviews.

These approaches for assessing the energy savings attributable to a program are based on determining NTGRs that have two main components: free ridership and spillover.

Free ridership refers to program participants who received an incentive but would have installed the same efficiency measure on their own had the program not been offered. This includes partial free riders, defined as customers who, at some point, would have installed the measure anyway, but the program persuaded them to

[9] ibid

install it *sooner* or customers who would have installed the measure anyway, but the program persuaded them to install more efficient equipment and/or more equipment. For the purposes of EM&V activities, participants who would have installed the equipment within one year will be considered full free riders; participants who would have installed the equipment later than one year will not be considered to be free riders (thus no partial free riders will be allowed).

Free ridership is the share of gross program savings that is generally the savings accounted for in program records and then adjusted for the naturally occurring adoption; the free ridership rate is based on actions participants "would have taken anyway" (i.e., actions that were not induced by the program). Each energy efficiency program covers a range of energy efficiency measures and is designed to move the overall market for energy efficiency forward. However, it is likely that some participants would have wanted to install some high efficiency measures (possibly a subset of those installed under the program) even if they had not participated in the program or been influenced by the program in any way.

Spillover refers to energy savings that are due to the influence of a program but are not counted in program records. For example, a customer installs a set of efficiency measures in one of his/her buildings. These measures were promoted (and incented) under a DSM program. The customer then decides to install the same measures at another site, where there is no program incentive. In this case, the program had an influence on the market beyond the energy savings in this customer's first building. Spillover can be broken out in three categories:

- *Participant Internal Spillover* represents energy savings from additional measures implemented by participants at participating sites not included in the program but directly attributable to the influence of the program.
- *Participant External Spillover* represents energy savings from measures taken by participants at non-participating sites not included in the program but directly attributable to the influence of the program.
- *Non-Participant Spillover* represents energy savings from measures that were taken by non-participating customers but are directly attributable to the influence of the program.

Spillover adds to a program's measured savings by incorporating indirect (i.e., not incented) savings and effects that the program has had on the market above and beyond the directly incented or directly induced program measures.

Total spillover is a combination of several factors that may influence non-reported actions to be taken at the project site itself (inside spillover) or at other sites by the participating customer (outside spillover). Each type of spillover is meant to capture a different aspect of the energy savings caused by the program, but not included in program records. Because a primary goal of most DSM programs is to transform markets through a variety of strategies – including education, promotion, and increasing awareness of the benefits of energy efficiency – one would expect spillover to occur to some extent in the market.

The overall NTGR is meant to account for both the net savings at participating projects and spillover savings that result from the program (but are not included in program records). When the gross program savings multiplies the NTG ratio, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program). The basic equation is:

NTG = 1 – Free ridership + Spillover

The underlying concept inherent in the application of the NTG formula is that only savings caused by the program should be included in the final net program savings estimate, but this estimate should include all savings caused by the program (i.e., the net program savings should account for free ridership and include spillover).

B.3.1.4.1. Estimating Free Ridership: Survey Techniques

Data to assess free ridership should be gathered through a series of survey questions asked of end-use customers and trade allies who participated in the program. Free ridership can be evaluated by asking direct questions, aimed at obtaining respondent estimates of the appropriate free ridership rate that should be applied to them, and by supporting, or influencing questions used to verify whether the direct responses are consistent with participants' views of the program's influence.

The direct free ridership questions ask respondents to estimate the share of measures that would have been incorporated at high efficiency if not for the technical and financial assistance of the program. The questions also ask respondents to estimate the likelihood that they would have incorporated measures "of the same high level of efficiency" if not for the technical and financial assistance of the program. This flexibility in how respondents conceptualize and convey their views on free ridership will allow respondents to provide their most informed response, thus improving the accuracy of the free-ridership estimates.

The "program influence" questions clarify the role that program interventions (e.g., financial incentives and technical assistance) played in decision-making and provide supporting information on free ridership. Responses to these questions are analyzed for each respondent and used to identify whether the direct responses on free ridership are consistent with how each respondent rated the "influence" of the program.

These results will then be compared to free ridership estimates based on on-site inspections/audits, and/or estimates derived from similar surveys completed in other jurisdictions.

B.3.1.4.2. Estimating Spillover: Survey Techniques

The basic method for assessing participant (inside and outside) spillover employs a three-step approach to determine the following:

1. Whether spillover exists at all. These are yes/no questions that ask, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records. Questions relate to extra measures installed at the project site (inside spillover) and to measures installed in non-program projects (outside spillover).

2. Extent of the spillover. These questions request information about the number or share of projects/jobs/facilities into which additional measures or technologies are installed (these questions are not asked for inside spillover because the value is simply the one project on which the interviewee focuses).

3. Amount of savings per spillover project. These questions ask respondents to estimate the energy savings associated with the non-recorded measures relative to the savings from the participating project itself.

The outcome of these inquiries is an estimate of the share of those non-recorded savings that can be attributed to the influence of the program.

B.3.1.4.3. Timing of Data Collection for Free Ridership vs. Spillover

Where possible, a staggered data collection approach should be used to collect information in support of NTG analysis. The rationale for this approach is that free ridership and spillover data are best collected at different points in time.

- Free ridership data are considered to be most accurate when collected as closely as possible to the point in time when the participation decision is made. Doing so helps to ensure accurate participant recall of motivating factors and relative program influence while also producing other benefits, including near-term feedback for program staff regarding program influence effects.
- Conversely, spillover data are considered most accurate when collected sometime after the participating project has been completed. Allowing a reasonable amount of time to pass before asking participants about spillover effects ensures that participants have sufficient time to: a) install the incented equipment, b) experience its operating parameters and costs, and c) then decide whether or not to install additional energy efficiency measures at the project site or some other location independent of any program support or financial incentive (Johnson et al., 2010).

B.3.1.4.4. Hierarchical Approaches for Determining When to Update NTG Values

A decision tree with several steps can be used to determine the timing for updating attribution analysis. The framework for updating net savings follows the hierarchical approach presented visually in Figure B-3. Each step in the decision is discussed in the following paragraphs.

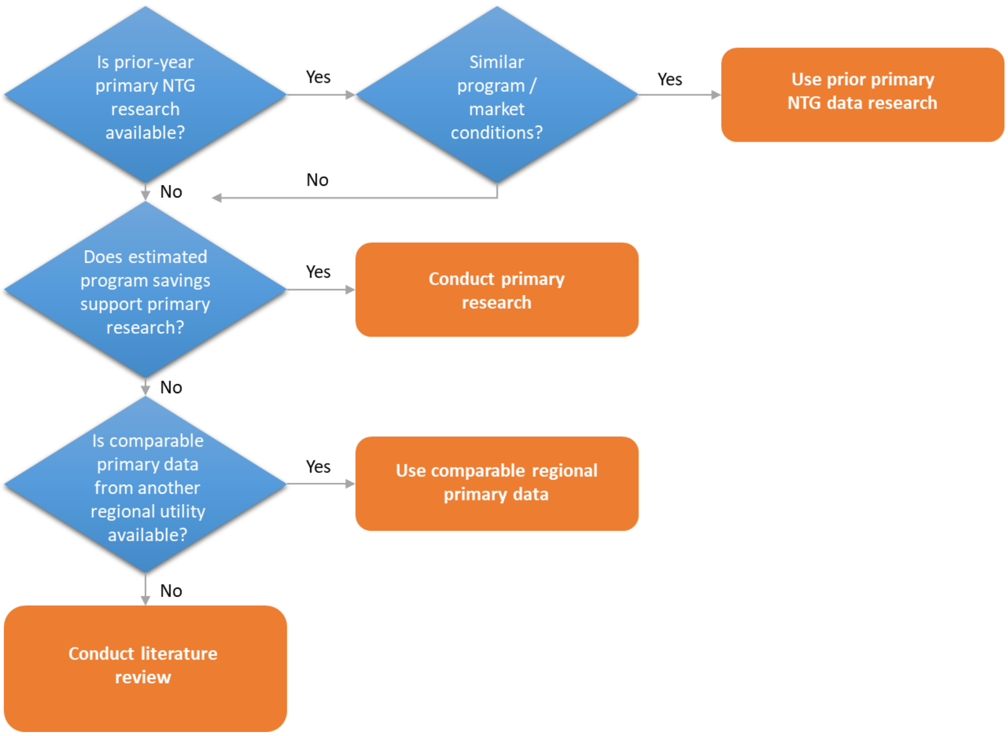


Figure B-3: Decision Tree for Timing and Selection of NTG Research

1. **Has NTG research been conducted on the same program in a prior year?** The first step to determining whether primary NTG research should be conducted in a given program year is to assess whether primary data collected for the same program are available from a prior year. If prior data are available, it should be determined whether the prior values are applicable in the current year. There are at least two overarching components of this decision.
   - First, determine if the current program is similar to the program in which the primary data was collected: Is the mix of measures the same? Is the contribution to savings for each measure similar? Are the incentive levels comparable? Is (are) the delivery method(s) similar?
   - Second, determine if the market conditions are similar to the time period in which the prior data were collected: Has there been a substantial change in incremental cost for the efficient measures? Has there been a substantial change in the supply or availability of the efficient measures? Has there been a substantial change in the market share of efficient measures (i.e., the ratio of efficient measures sold to total comparable standard and efficiency measures)? Are the local or federal codes and standards the same as when the prior NTG values were estimated?

If the program and market conditions are comparable to the time period(s) in which the prior primary NTG research was conducted, these prior values can be considered applicable to the current program year.

2. **If prior year primary data are not available or are determined not to be applicable due to changes to either program or market conditions.** The TPE should then determine whether estimated savings from the program support primary research. In general, programs that represent at least 5-10 percent of the portfolio estimated savings in any given year should use NTG ratios that are estimated via primary data research for that specific program.

3. **If prior year data for the program are not available or applicable, and the program savings does not support primary data collection.** The evaluation should then consider if NTG values derived from Arkansas-based comparable programs are available. A comparable program is defined as one that is similar in terms of program maturity, incentive levels, delivery mechanism, and measure types. Ideally, NTG values derived in the same program year would be used, but values from prior years may also be used if the comparability conditions are met.

4. **For existing and new programs that do not meet any of the above specifications.** A literature review may be undertaken to locate a similar program (or programs) that has (or have) an established NTG value(s). This approach requires that the research be well documented. A program may be identified as similar if it meets the following conditions:
   - *Program Similarity*: maturity, incentive levels, delivery mechanism, and measure types are similar; and
   - *Market Similarity*: demographic, household, and business characteristics are similar (or as similar as possible) to those for New Orleans.

With this hierarchical approach, evaluation resources can be directed towards programs that could benefit most from primary research, thus avoiding unnecessarily repeating NTG research every year for the same programs. However, to prevent NTG values from being repeated too many years and becoming potentially "stale", NTG values for programs that meet the contribution to savings threshold should be updated at least via primary research at least once during every three-year program cycle.

The steps along this decision tree should be clearly presented and discussed as part of program evaluation plans.

Evaluations using trade ally responses should be collected for programs where the trade allies play a key role in the installation decision. The evaluation work plan should present a discussion of the representation from the trade ally respondents. If use of information supplied by trade allies is applicable, evaluation plans should include details regarding how trade ally responses will be integrated with customer survey responses to determine overall program attribution.

Annual EM&V reports should include robust reporting related to NTG research, methods, and findings. To ensure consistency and transparency in reporting, an annual EM&V report should include the following information regarding NTG analyses.

- *Summary of each programs NTG source*. For example, a table could show which programs received updated NTG research versus those where NTG analysis used previous values, deemed values, or secondary research.
- *Discussion of rationale for use of previous estimate or literature review*. EM&V Reports should cite evidence that the delivery, incentives, measures, and program design were unchanged.
- If unique NTG values are assigned to distinct program components, then each component should be reported with gross and net savings contributions. Where different program components (e.g., measures) have different NTG values, savings for each program component should be presented along with the respective NTG values.
- It is recommended that an appendix be included in the report that details NTG approach and methods. This appendix should include the following:
  - *High-level discussion of approach and methods***.** A methods section should detail the overarching NTG approach across programs, especially if the same algorithms and logic are used across multiple programs.
  - *Detailed discussion of logic* (*including questions, full battery of survey question*)*.* Complete survey battery logic, flow-charts, and comprehensive details of the program NTG approach should be included in the appendix.
  - *Discussion of program-specific logic in each section***.** If individual program NTG research includes customized logic that is distinct from the overall approach included in the methods section, then the differences in approach should be reported within each individual program section.

B.4. Protocols for Conducting Process Evaluations

This protocol provides guidance regarding scope and timing for process evaluation of a programs. A process evaluation involves examining the process of implementing a program and determining whether the program is operating as planned. The goal of a process evaluation is to recommend ways to improve processes to increase a program's effectiveness. A process evaluation focus on determining the overall effectiveness of program delivery, identifying opportunities for program improvements and assessing key program metrics, including participation rates, market barriers, and overall program operations.

B.4.1.1. Process Protocol 1: Determining Whether to Conduct a Process Evaluation of a Program

Two major criteria can be applied to determine if a process evaluation of a program is needed.

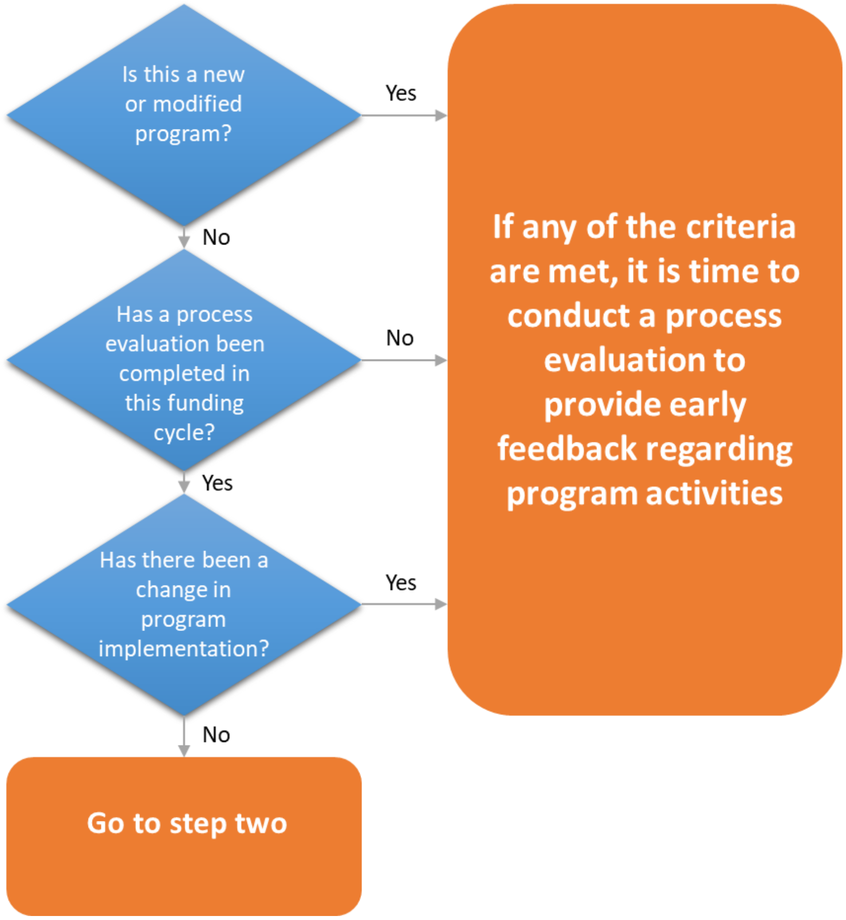
- The first criterion is to determine if it is time for a process evaluation;
- The second criterion is to determine if there is a need for a process evaluation.

Table B-5 addresses the first criterion, setting out conditions for determining what timing is appropriate for conducting a process evaluation.

Table B-5: Determining Appropriate Timing to Conduct a Process Evaluation

1. **No Previous Process Evaluation**: If a program has not had a comprehensive process evaluation, conducting a process evaluation should be considered.
2. **New and Innovative Components**: If a program has new or innovative components that have not been evaluated previously, then a process evaluation should be considered for assessing their level of success in the current program and their applicability for use in other programs.
3. **New Vendor or Contractor**: If a program is a continuing or ongoing program but is now being implemented, in whole or in part, by a different vendor than in the previous program cycle, then a process evaluation should be considered to determine if the new vendor is effectively implementing the program.
If any of these criteria are met, it is time to conduct a process evaluation.
If none of these criteria are met, proceed to Table 2 (Step 2) in the Process Evaluation Decision Map.

Figure B-4 provides a flow chart for determining whether it is time to perform a process evaluation of a program.



(Source: Arkansas TRM Version 7, modified for formatting)

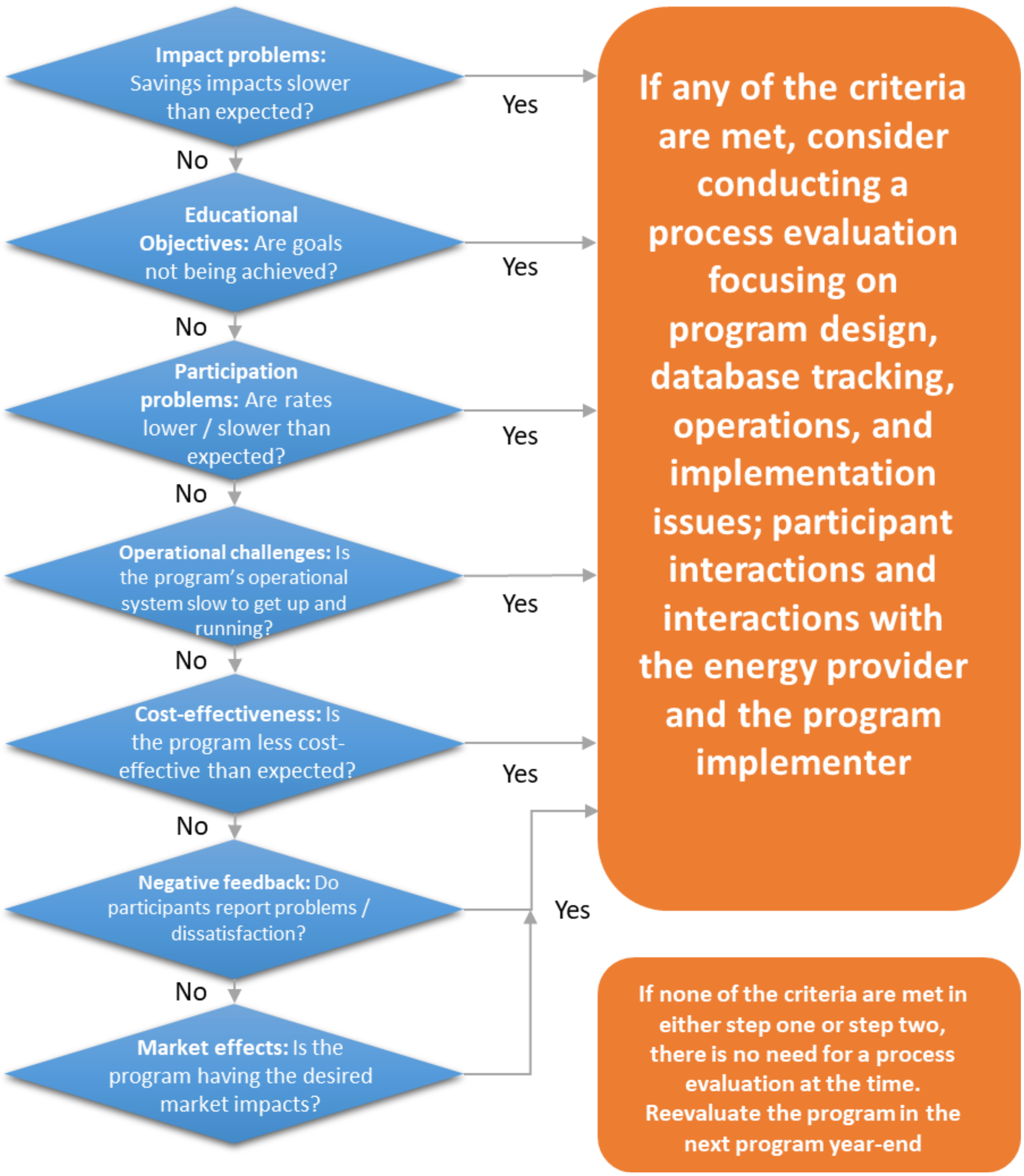
Figure B-4: Determining Timing for a Process Evaluation

Process evaluations may be used to diagnose areas where a program is not performing as expected. Conditions to consider in this respect are shown in Table B-6.

Table B-6: Determining Appropriate Conditions to Conduct a Process Evaluation

Conditions appropriate to conducting a process evaluation may include the following:
1. Impact Problems: Are program impacts lower or slower than expected?
2. Informational/Educational Objectives: Are the educational or informational goals not meeting program goals?
3. Participation Problems: Are the participation rates lower or slower than expected?
4. Operational Challenges: Are the program's operational or management structure slow to get up and running or not meeting program administrative needs?
5. Cost-Effectiveness: Is the program's cost-effectiveness less than expected?
6. Negative Feedback: Do participants report problems with the program or low rates of satisfaction?
7. Market Effects: Is the program producing the intended market effects?
If any of the criteria is met, a process evaluation is needed to identify ways to address and correct these operational issues.
If none of these criteria is met in either Step 1 or Step 2, then a process evaluation is not needed at this time.
Re-evaluate the need for a process evaluation at the end of the program year.

Figure B-5 defines the method to identifying problems in program administration that may warrant a process evaluation.



(Source: Arkansas TRM, Version 7, modified for formatting)

Figure B-5: Determining Need to Conduct a Process Evaluation

Throughout an evaluation cycle, limited or focused process evaluation activities (e.g., review of program database, interviews of staff) may be used to determine interim progress for a program. Findings from focused process evaluation activities serve several purposes.

- Provide a progress report for each recommendation for program improvement made in previously conducted evaluations. For each evaluation recommendation, the report should indicate whether the recommendation has been accepted and implemented, rejected, or is still under consideration. If the recommendation is rejected, an explanation of the reason for rejection should be provided. If a recommendation is still under consideration, then an explanation should be provided for the steps underway to reach an implementation decision for that recommendation;
- Identify progress made towards achieving program objectives;
- Identify any issues that may need to be explored more fully in future program evaluations.

B.4.1.2. Process Protocol 2: Planning Process Evaluation

This protocol provides guidance on the key issues that should be addressed in planning process evaluation activities. Aspects of program operations to address any deficiencies identified in Figure B-5.

Three tables are provided that outline the key researchable issues that should be addressed in a process evaluation.

- Table B-7 provides a general outline of the key elements that should be included in a process evaluation plan.
- Table B-8 provides more detailed information regarding the key areas for investigation that need to be addressed in a process evaluation.
- Table B-9 identifies those topic areas that should be covered in all process evaluations, those areas that should be investigated when the program is experiencing specific operational issues or challenges, and those areas that are most applicable to new programs or pilot programs.

Table B-7: Recommended Elements of a Process Evaluation Plan

Element	***Description***
Introduction	Description of the program or portfolio under investigation; specific characteristics of the energy organization providing the program including current marketing, educational or outreach activities and delivery channels
Process Evaluation Methodology	Process evaluation objectives, researchable issues, and a description of how specific evaluation tactics will address the key researchable issues including the proposed sampling methodology for program/third-party staff, key stakeholders, trade allies/vendors, and customers. The sampling methodology should be clearly explained with specific targets of completed surveys or interviews clearly described in the EM&V Plan.
Timeline	Summarized by key tasks identifying the length of the process evaluation and key dates for completion of major milestones
Budget	Costs of conducting the process evaluation by specific tasks and deliverables

Source: Modified and Expanded from the California Evaluation Protocols, 2006, (as presented in Arkansas TRM Version 7).

Table B-8: Recommended Areas of Investigation in a Process Evaluation

Program Design	**Additional Guidance**
▪ Program mission, vision and goal setting and goal setting process ▪ Assessment or development of program and market operations theories ▪ Program design and design characteristics, and program design process ▪ Use of new or best practices	This area is especially important to address in first-year evaluations and evaluations of pilot programs.
Program Administration ▪ Program management process ▪ Program staffing allocation and requirements ▪ Management and staff skill and training needs ▪ Program tracking information and information support systems ▪ Reporting and relationship between effective tracking and management, including operational and financial management	**Additional Guidance** This area should be covered in all process evaluations, but it is especially important to address in those evaluations where operational or administrative deficiencies exist.
Program Implementation and Delivery	**Additional Guidance**
▪ Description and assessment of program implementation and delivery process	This is critical to gathering the information necessary to assess the program's operational flow.
▪ Program marketing, outreaching, and targeting activities ▪ Quality control methods or operational issues ▪ Program management and management's operational practices ▪ Program delivery systems, components and implementation practices	These are areas that should be addressed if program is not meeting its participation goals or if the program is under-performing.
▪ Program targeting, marketing and outreach efforts	All marketing and outreach materials should be reviewed and assessed as part of document review task.
▪ Program goal attainment and goal-associated implementation processes and results ▪ Program timing, timelines and time-sensitive accomplishments	These areas should be addressed in all process evaluations but are especially important if the program is under- performing regarding savings or participation rates.

Table B-9: Recommended Areas of Investigation in a Process Evaluation

Areas of Investigation	***Additional Guidance***
Documentation of program tracking methods and reporting formats	This is a key element of the review of the program database and the TPE should request copies of the program records or extracts along with the data dictionary.
Customer interaction and satisfaction (both overall satisfaction and satisfaction with key program components, including satisfaction with key customer- product-provider relationships and support services)	These topics should be investigated in customer surveys and should be a priority if the program is experiencing negative feedback or lower-than-expected participation rates or energy savings.
Customer or participant's energy efficiency or load reduction needs and ability of program to deliver on those needs	
Market allies' interaction and satisfaction with program	
Reasons for low level of market effects and spillover	
Intended or unanticipated market effects	

B.4.1.3. Process Protocol 3: Process Evaluation Report and Recommendations

The suggested reporting requirements for a process evaluation report are given in Table B-10.

Table B-10: Suggested Reporting Requirements for Process Evaluation Report

Suggested Reporting Requirement	***Description***
1. Detailed Program Description	Process evaluation report should present a detailed operational description of the program that focuses on program components being evaluated. The use of a program flow model is highly recommended. Report should provide sufficient detail so that a reader can understand program operations and likely results of recommended program changes.
2. Program Theory	Process evaluation report should include a presentation of the program theory. If the program theory is not available or cannot be provided in time for the evaluation report due date, a summary program theory built from the evaluation team's program knowledge may be included instead. However, it should be complete enough for a reader to understand the context for program recommendations. It does not need to be a finely detailed program theory or logic model.
3. Support for Recommended Program Changes	All recommendations need to be adequately supported. Each recommendation should be included in the Executive Summary and then presented in the Findings text along with the analysis conducted and the theoretical basis for making the recommendation. The Findings section should also include a description of how the recommendation is expected to help the program, including the expected effect that implementing the change will have on the operations of the program.
4. Detailed Presentation of Findings	A detailed presentation of the findings from the study is essential. The presentation should convey the conditions of the program being evaluated and should provide enough detail so that any reader can understand the findings and the implications of the overall operations of the program and its cost-effectiveness

(Modified from the CA Evaluation Protocols 2006).

Table B-11 provides guidance on structuring recommendations from a process evaluation.

Table B-11: Suggested Structuring of Recommendations from Process Evaluation

Recommendations from a Process Evaluation should be:
Realistic, appropriate to Entergy New Orleans' structure, constructive, and achievable using available resources
Linked to specific conclusions
Adequately supported. Each recommendation should be included in the Executive Summary of the report and then presented in the findings text along with analysis conducted and theoretical basis for making recommendation. Findings section should include a description of how recommendation is expected to help the program, including the expected effect implementing the change will have on the operations of the program.
Focused on ways to increase overall program effectiveness and be linked to researchable issues addressed in process evaluation (e.g., ways to improve program design, approach, operations, marketing, or address issues related to program under-performance)
Providing specific steps / tasks for implementation (to extent possible)
Compared across program evaluations to identify areas for portfolio-level improvements

(Source: Modified from the CA Evaluation Protocols, 2006, as presented in Arkansas TRM Version 7)

B.5. Protocols for Evaluation of New Construction Projects

B.5.1. Description

This protocol is intended to describe the recommended method when evaluating the whole building performance of new construction projects in the commercial sector. The protocol focuses on energy conservation measures (ECMs) or packages of measures where evaluators can analyze impacts using building simulation. These ECMs typically require the use of calibrated building simulations under Option D of the International Performance Measurement and Verification Protocol (IPMVP).[10]

Examples of such measures include Leadership in Energy & Environmental Design (LEED) building certification, novel and/or efficient heating, ventilation, and air conditioning (HVAC) system designs, and extensive building controls systems. In general, it is best to evaluate any ECM expected to significantly interact with other systems within the building and with savings sensitive to seasonal variations in weather.[11] The protocol classifies commercial new construction projects as:

- **Newly constructed buildings:** The design and construction of an entirely new structure on a greenfield site or wholesale replacement of a structure torn down to the ground.
-
- **Addition (expansion) to existing buildings**: Significant extensions to an existing structure that requires building permits and triggers compliance with current codes.
-
- **Major renovations or tenant improvements of existing buildings:** Significant reconstruction or "gut rehab" of an existing structure that requires building permits and triggers compliance with current codes.

Evaluators may need to apply the evaluation methods described here for new construction projects for some projects in the retrofit programs. While some retrofit projects have much in common with new construction projects, their scope does not uniformly fall under the new construction categories previously described. Evaluators should assess these projects according to the guidelines described for retrofit equipment (described in separate protocols).

Evaluation, measurement, and verification (EM&V) of new construction programs involves unique challenges, particularly when defining baseline energy performance. An

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[10] 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.

[11] Note the term whole-building modeling does not necessitate use of sophisticated stand-alone simulation software (e.g., eQUEST, EnergyPlus). It is acceptable to employ engineering models using spreadsheet calculations, provided they meet the guidelines set forth in Section 4

agreed-upon building energy code or industry standard defines the baseline equipment evaluators use to measure energy impacts for new construction measures. As the baseline equipment for new construction measures does not physically exist and cannot be measured or monitored, evaluators typically employ a simulation approach. Due to the nuances involved in appropriately determining baseline equipment/performance evaluations, experienced professionals with a good understanding of building construction practices, simulation code limitations, and the relevant building codes should oversee these types of projects.

Further, evaluators typically assess new construction measures within the first few years of construction. During this period, there is often considerable change in building occupancy and operation before the measures design intent becomes realized. This results in additional challenges for evaluators using monitored data and/or facility utility billing or energy consumption history to define as-built building performance.

B.5.2. Application Conditions of Protocol

Use the algorithms and protocols described here to evaluate new construction whole-building performance ECMs installed in commercial facilities. When new construction ECMs do not directly impact HVAC energy use, it is often possible to use spot measurements and engineering calculations to evaluate savings with sufficient rigor (ASHRAE 2002). This is usually the case, for example, with lighting and domestic hot water retrofits.[12] This protocol does not cover the guidelines for selecting the appropriate monitoring and verification (M&V) rigor for such measures. Consult the IPMVP or measure-specific protocols within the Uniform Methods Project protocols to review evaluation guidelines for measures that do not require calibrated building simulation.

B.5.2.1. Incentive Types

Program administrators typically classify new construction demand-side management (DSM) program incentives as being either component-based or performance-based and design the program to offer one or both types of incentives.

B.5.2.1.1. Component-Based Incentives

Component-based (or “prescriptive”) incentives tend to involve individual technologies and equipment. Examples of prescriptive incentives may include lighting fixtures, occupancy sensors, motors, and small packaged (unitary) HVAC units. Evaluators often determine rebate amounts and claimed savings estimates based on stipulated per-unit

[12] While the general magnitude of the secondary impacts imparted by lighting measures on HVAC equipment are well-established for various building types, take care to estimate these impacts appropriately in new construction building stock. New buildings typically have more efficient HVAC equipment, which reduces the magnitude of heating and cooling interactive effects. Secondary impacts can be estimated using prototypical building models, representative of the physical facility. See the Uniform Method Project’s Chapter 2: Commercial and Industrial Lighting Evaluation Protocol or CPUC 2004 for guidelines regarding HVAC interactive factors.

estimates.[13] Evaluators will sometimes assess component-based rebates according to measure-specific protocols using partial or complete retrofit isolation evaluation strategies (IPMVP Option A or Option B).

B.5.2.1.2. 2.1.2 Performance-Based Incentives

Performance-based incentives tend to target more complex projects involving improvements to the overall building energy performance. Whole-building performance incentives can:

- Encompass various specific (above-code) upgrades
- Fund design, analysis, equipment, and/or installation (labor) costs.[14]

An example of a performance-based project is LEED certification. Buildings that are LEED certified often encompass ECMs that range from envelope improvements to high-efficiency equipment installations (often going beyond just HVAC) and complicated controls algorithms.

The complex interactions between these ECMs can only be reliably determined through the use of calibrated building simulation models.

Performance-based incentive amounts are typically determined by the expected annual energy and/or demand impacts (e.g., per kilowatt-hour, therm, kilowatt).[15] Annual energy-savings estimates for performance-based projects (and programs) require evaluators to use custom calculations via whole-building simulation modeling tools. Therefore, highly skilled technical labor is required to successfully implement and evaluate these programs.[16]

B.5.3. Savings Calculations

Use the following algorithm to calculate energy savings for new construction measures. Note that evaluators can calculate demand savings using the same algorithms by simply substituting “demand” for “energy use.”[17]

Equation 1

$$Energy\ Savings = Projected\ Baseline\ Energy\ Use - Post\ Construction\ Energy\ Use$$

Where:

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[13] Units used do not necessarily represent quantity. Frequently applied units include: installed horsepower, tons of refrigeration, and square footage.

[14] Some new construction programs have been successfully implemented without direct financial incentives (design assistance, financing, etc.).

[15] Depending on program design, the “expected” energy impacts can be either ex ante or ex post.

[16] See Johnson & Nadel 2000 for more information.

[17] When calculating the coincident peak demand savings, average the hourly demand savings over the “peak demand window” period, as defined by the utility.

$Projected\ Baseline\ Energy\ Use =$ Projected energy use of baseline system at full designed occupancy and typical building operating conditions.

$Post\ Construction\ Energy\ Use =$ Energy use of measure systems at full design occupancy and typical building operating conditions.

As described in Section 4, *Measurement and Verification Plan,* calculate projected baseline energy use and post-construction energy use using a whole-building simulation model that is calibrated to monthly (or hourly) utility energy consumption histories. Evaluators can use four components to report savings for new construction ECMs:

- Expected (planned) measure savings
- Rebated measure savings
- Non-rebated measure savings
- Total achieved savings

Section 4 discusses each component.

B.5.4. Measurement and Verification Plan

B.5.4.1. International Performance Measurement and Verification Protocol Option

The preferred approach to calculate savings for whole-building performance new construction projects is calibrated building simulation models according to IPMVP Option D (IPMVP 2006). The recommended approach requires sufficient resources be allocated to the project to allow for detailed onsite data collection, preparation of the simulation models, and careful calibration. The method is less costly when a functioning ex-ante model is available to the evaluator, though obtaining the ex-ante model is not a prerequisite to its application.

Determine the appropriate modeling software by the specifics of the evaluated buildings (e.g., HVAC system and zoning complexity, building constructions, complexity of the ECMs); there is no single software (currently available) that can simulate all variations of HVAC system types, building constructions, and ECMs. Thus, it may be necessary to use multiple tools to evaluate building performance accurately.

In general, the appropriate software for modeling building systems and energy performance must:

- Create outputs that comply with American National Standards Institute (ANSI)/ASHRAE Standard 140-2011[18]
- Accurately simulate the building's systems and controls

[18] ANSI/ASHRAE Standard 140-2011 establishes test procedures validating software used to evaluate thermal performance of buildings (and applicable HVAC equipment).

- Use an hourly or sub-hourly time step to perform simulation[19]
- Simulate building performance using user-defined weather data at hourly intervals

For more information on specific requirements for simulation software, see pp. 133 in *The California Evaluation Framework* (CPUC 2004) and pp. 26-27 in *Appendix J – Quality Assurance for Statistical, Engineering, and Self-Report for Estimating DSM Program Impacts* (CADMAC 1998). [20]

The U.S. Department of Energy's (DOE) Energy Efficiency and Renewable Energy website[21] contains a list of building energy simulation software. Although some tools listed are proprietary, the website also lists public-domain DOE-sponsored tools. Summary comparisons and descriptions of commonly used software can be found in Crawley (2005).

The preferred full Option D approach will in some cases be intractable due to limited data availability or evaluation budgetary limitations. In such cases, alternate methodologies are acceptable but the following guidelines should be followed:

- Onsite verification and review of as-built drawings and commissioning reports (as available) should be performed to verify which energy saving features were actually installed and are functioning
- Ex-ante savings calculations should be based in a whole building simulation model of the building or of a building that is representative of the actual facility
- Results should be compared with billing data (when available), engineering rules of thumb, and/or secondary literature to review reasonability.

B.5.4.1.1. Verification Process

Figure 1 depicts the overall process to verify savings under Option D, from The *California Evaluation Framework* (CPUC 2004). The process starts by specifying which site data collection and equipment monitoring requirements are in an M&V plan. Additionally, the M&V plan should specify:

The applicable version of the building codes and equipment standards that determine the baseline (or applicable 'practice' that may determine baseline). This is discussed in more detail in Section 4.3.

- The above-code technologies present in the building (claimed as ECMs)
- The software for modeling building performance
- Appropriate data for calibrating the simulations
- How to address modeling uncertainties

[19] It is preferable the software use unique time steps for each interval (e.g., 8,760 hours).

[20] For further commentary on simulation software requirements, see ASHRAE 2002, IPMVP 2001, and IPMVP 2006.

[21] The DOE's Energy Efficiency and Renewable Energy website can be found at: http://apps1.eere.energy.gov/buildings/tools_directory/.

- Against what statistical indices calibration will be measured.

While reviewing the energy consumption data can be useful in developing data collection needs, it is not a prerequisite to creating and implementing the M&V plan. However, when developing the M&V plan, evaluators should consider how long a building has been occupied because that will determine amount and granularity of energy consumption data available. Fewer months of consumption data, or the availability of only monthly data, usually means there will be a greater emphasis on metering specific pieces of equipment. Conversely, the presence of a building automation system, energy monitoring system, lighting control panels, (collectively referred to here as building automation system) or other devices to control and/or store data about the operational characteristics of the building will allow for a lesser dependence upon utility usage data.

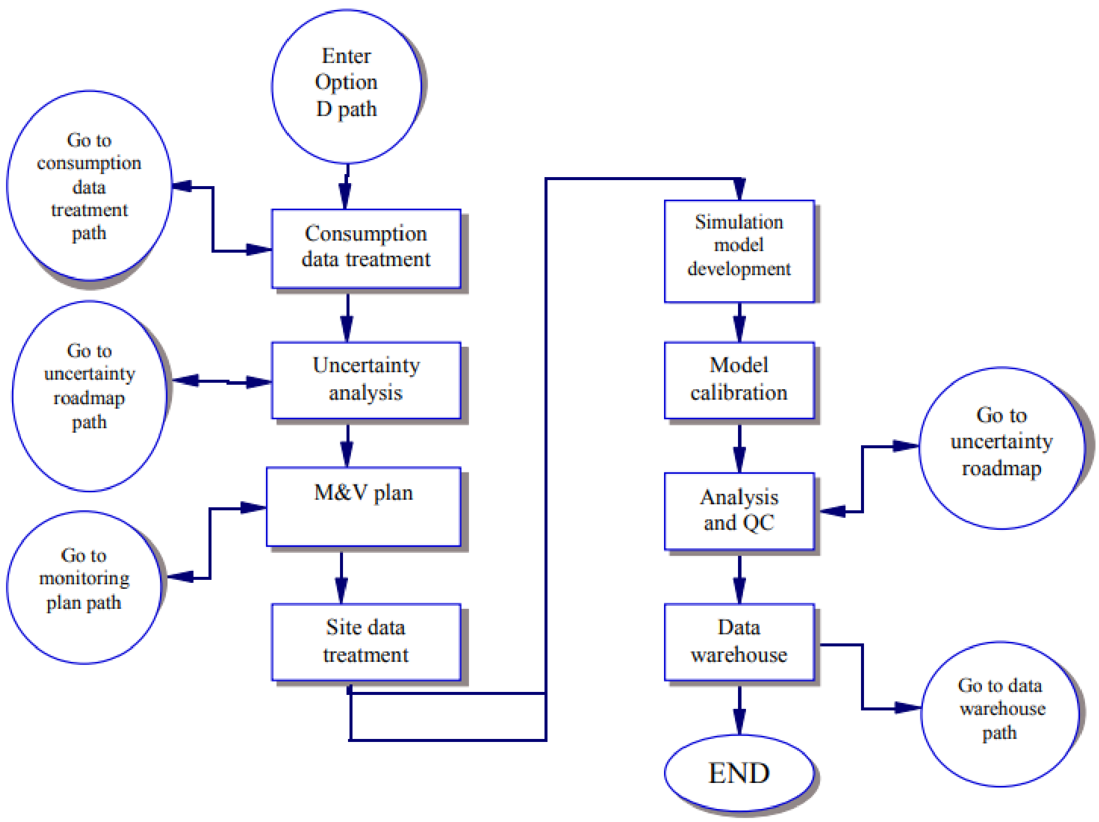

Figure 6: Roadmap for IPMVP Option D

B.5.4.1.2. Data Requirements and Collection Methods

Data collected during this step includes all of the information required to define and calibrate the building simulation model. Due to the unique nature of each new construction project, it is impractical to prescribe a comprehensive list of specific parameters evaluators should collect on site. Instead, use the following guidelines to identify key data points and minimize the uncertainty in the final calibrated simulations. After identifying specific parameters, refer to the Uniform Methods Project's *Metering Cross-Cutting*

Protocols for instructions regarding the methods to submeter the physical parameters. The data used to define building simulation models come from stipulated and physical sources. Furthermore, these data can be static or dynamic in nature, as described here:

- *Static data points*. These are essentially constant values that describe physical properties of the equipment and the building surfaces or the set point and operational range controlling the building equipment.[22] Examples of static data points are window glazing, motor efficiencies, and thermostat set points.
- *Dynamic data*. These are time-dependent variables that describe building and equipment operations. These data capture the behavioral and operational details (e.g., weather, motor loading, and building occupancy) needed to establish a building's energy-use characteristics. Dynamic data, which are often the most difficult to collect, represent the greatest source of uncertainty in a building simulation.

IPMVP Option D (IPMVP 2006) allows use of stipulated data, although it is important to minimize the number of these inputs, as they represent degrees of freedom (and, therefore, additional uncertainty) in the model. Sources for such data include peer-reviewed research, engineering references, simulation program defaults, manufacturers' specifications, and/or survey information from on-site visits (e.g., mechanical and architectural drawings and visual inspection of nameplate information).

The following are convenient categories of important physical data to collect on site (ASHRAE 2002):

- Lighting systems
- Plug loads
- HVAC systems
- Building envelope and thermal mass
- Building occupants
- Other major energy-using loads.[23]

Another important element of the data collection process entails the use of submetering to define behavioral and dynamic aspects of a building and its subsystems. In this protocol, the term submetering encompasses both direct placement of monitoring equipment by evaluation personnel and collecting data from the building automation systems (also known as trend data) when available. Even when the absolute accuracy of the collected data is unknown, submetered data is useful for informing operational schedules (e.g., lighting and ventilation) and calibrating the model.

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[22] 3 Set points can refer to a control zone, thermostat, control valve, flow rate, voltage, photocell, or other parameter that is designed to maintain optimal environmental conditions within the building. Some set points are "dynamic" in that they may change according to the time of day.

[23] This category is particularly important in buildings such as grocery stores, refrigerated warehouses, and some retail.

The degree of submetering required is largely dependent upon the quality and resolution of the facility's energy consumption history. The following descriptions of submetering represent the minimum amount of data collected for calibrating simulation models. Additional submetering may be necessary to verify complex control schemes and/or set points. Perform additional submetering as budget and time permit.[24] Use such data to inform model inputs rather than to function as a calibration target.

B.5.4.1.2.1. Submetering With Monthly Bills

When only a monthly utility billing history is available for a facility, it is important to submeter both HVAC fan schedules[25] and interior lighting fixtures. Also, if the facility has unique or considerable equipment loads (e.g., data centers), meter these as well.

When monitoring unitary HVAC equipment, isolate the power used by fans from that used by compressors. This ensures evaluators can use the resulting data when calibrating time-of-use and magnitude of fan power.

If, due to site or budget limitations, the electrical monitoring must comprise the unitary system as a whole, use motor nameplate information and fan curves in conjunction with local weather data to disaggregate the fan and compressor power.[26]

Alternatively, use one-time power measurements to establish a unit's demand for each operation mode. Combine these measurements with time-series data to identify time spent in each operation mode and, thereby, determine the fan schedules.

B.5.4.1.2.2. Submetering With Hourly Bills

Hourly (or sub-hourly) energy consumption histories contain much more information for model calibration than monthly usage alone. While this additional information reduces submetering requirements, it does not eliminate the need to submeter HVAC fan schedules as they are important for disaggregating base loads from ventilation. As described for monthly billing data, consider submetering other large energy-using features (e.g., pool-heating and space-cooling equipment, atria lighting, and internet technology loads) if possible given evaluation budgets.

B.5.4.2. Simulation Model Development

It is important to model several iterations of the simulated building so as to fully capture the various aspects of the savings for new construction ECMs. Table 1 lists this iterative

[24] For example, verifying functionality of chilled water reset controls or condensing water relief set points

[25] It is important to capture a building's ventilation schedule when HVAC systems are used to supply outside air to maintain required fresh requirements. If performing submetering on a sample of HVAC fans, place priority on accurately capturing when (and how much) outside air is introduced into the building.

[26] To employ this method, the modeler must have the requisite expertise to apply appropriate statistical and engineering modeling techniques to perform this analysis. For further information on energy consumption analysis, see the Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol.

process, which entails three versions of the as-built building and two versions of the baseline building, including:

- As-built physical
- As-built design
- As-built expected design
- Whole-building reference
- Measure building reference.

Table 1 does not include intermediate modeling of individual ECMs. Intermediate modeling can be used to disaggregate individual measure impacts and interactive effects. If measure-level savings estimates (and therefore, intermediate modeling of measures) is required, work with the governing jurisdiction for the evaluation process to establish an appropriate hierarchy to govern the order in which measures are stacked and individual measure savings assessed.

Table 1. List of Models Used To Simulate Savings for New Construction ECMs

Model	Model Name and Purpose	Model Description
1	As-Built Physical *To calibrate simulations and assess uncertainty*	Model and simulate, as found during site visit. Use the occupancy and building operation, as reflected in billed energy history and submetered data. Simulate using actual local weather observations matching the consumption history period.
2	As-Built Design *To estimate typical usage at full occupancy*	Base on as-built physical model. Use full design occupancy and expected typical building schedules. Use construction and equipment efficiencies, as found during site visits. Simulate using normalized weather data (e.g., typical meteorological year [TMY] datasets).[a]
3	As-Built Expected Design *To estimate difference between original and as-built models*	Base on as-built design model. Use full design occupancy and expected typical building schedules. Use assumed constructions and equipment efficiencies. Simulate using normalized weather data (e.g., TMY datasets).
4	Whole-Building Reference *To estimate savings of the ECMs*	Base on as-built design model. Use full design occupancy and expected typical building schedules. Apply baseline requirements defined by reference codes or standards. Simulate using normalized weather data (e.g., TMY).
5	Measure Building Reference *To isolate savings claimed by the participant*	Base on whole-building reference model. Use full design occupancy and expected typical building schedules. Apply baseline requirements defined by reference codes or standards. Include ECMs not incentivized by DSM program. Simulate using normalized weather data (e.g., TMY).

[a] Note the TMY are referenced here as an example series of normalized weather data. When incorporating TMY weather data, use TMY3 weather data when available. While TMY weather represents a common standard, review the reporting needs of the project, as other normalized weather datasets may be more appropriate (e.g. Weather year for Energy Calculations [WYEC] or California Thermal Zones [CTZ]).

Begin the development of the model by generating a model of the building as it was built and is operating during the site visit—and as reflected by utility energy consumption data. Use this initial model, the as-built physical model, to calibrate the modeled building to available physical data. This ensures evaluators can use successive iterations in a predictive capacity. A detailed discussion of the calibration process falls outside the scope of this protocol; however, for detailed calibration procedures and guidelines see Section 6.3.3.4 in ASHRAE Guideline 14- 2002 (ASHRAE 2002).

Once calibrated, use the as-built physical model to generate the as-built design model, which should reflect the building at full-design occupancy and operation according to expected typical schedules. The only differences between these models are building occupancy, operational schedules, and any modeling guidelines incorporated from codes or standards used to define baseline performance. For buildings currently operating at full occupancy, there may be very little difference between these models. Refer to Tables 11.3.1 and G3.1 in ASHRAE Standard 90.1-2007 (ASHRAE 2007) for examples of modeling requirements specified by codes and standards.

Then, use the as-built design model to generate the as-built expected design model. While this model simulates the building's operation according to its design intent, it also includes claimed assumptions regarding envelope constructions and equipment efficiencies. Review the model for discrepancies between claimed assumptions and the physical building; if no discrepancies exist, this model will be identical to the as-built design.

After developing as-built models, evaluators can model baseline building performance, which results in the whole-building reference model; to generate this model, apply the appropriate codes and standards used to define baseline building performance to the as-built design model. The M&V plan should identify such standards before modeling begins. The following section, *Baseline Considerations,* discusses additional considerations for baseline selection. Similar to the as-built design model, the whole-building reference model should reflect the building's operation according to its expected long-term patterns while using equipment and construction that minimally complies with the reference code or standard.

Finally, start with the whole-building reference model to generate the measure building reference model—this model will include ECMs not incentivized by the DSM program. It is likely all the implemented ECMs are included in the whole-building performance incentives; therefore, both the baseline models may be identical. However, as incentives often are applied for during the building's design and construction process, additional above-code equipment or construction may be implemented that were not included in the final incentive.

B.5.4.3. Baseline Considerations

Defining baseline building physical characteristics and equipment performance is one of the most important (and difficult) tasks in evaluating savings for new construction ECMs. This is for several reasons. As noted, new construction ECMs do not have a physical baseline to observe, measure, or document. Rather, evaluators must define the baseline "hypothetically" through an *appropriate* interpretation of the applicable energy codes and standards. It is typically complicated to establish an appropriate interpretation due to the overlapping scope of federal, state, and local codes. Conversely, some states do not have a building energy-efficiency standard separate from the federal standards. Typically, evaluators determine baseline building characteristics and equipment performance requirements by locally adopted building energy codes. In some cases, however, applying a more rigorous, above-code baseline may better reflect standard local construction or industry-standard practices. Thus, in addition to a good understanding of the relationship between federal, state, and local standards, evaluators may need to consult with program guidelines (which often specify greater than code stringency or other technical specifications) or statewide evaluation frameworks. Enforcement of the state codes is the responsibility of the local building officials. The EM&V effort of energy-efficiency programs is usually carried out by utility or other program administrators or by a public utilities commission. Whereas the public utilities commission usually has no enforcement responsibility for the codes and standards, they often point to the official state standards as the governing document regardless of the degree of enforcement of those codes at the local level.

In general, the baseline must satisfy the following criteria (IPMVP 2006):

- It must appropriately reflect how a contemporary, nonparticipant building would be built in the program's absence.[27]
- Evaluators must rigorously define it with sufficient detail to prescribe baseline conditions for each individual ECM and for the building components simulated.
- Evaluators must develop it with sufficient clarity and documentation to be repeatable.

The BCAP-OCEAN website (http://energycodesocean.org) can be a useful resource in identifying locally adopted energy codes and standards when starting the evaluation of a wholebuilding or commercial new construction project.

B.5.4.4. Calculating Savings

To calculate savings, apply simulation outputs (from models 2 through 5 in Table 2) to the formulas described in Section 3. In all cases except as-built physical, simulate the postconstruction energy use and the projected baseline energy use using normalized weather data (TMY).

As discussed in Section 3, there are four components that comprise calculated energy savings (defined in Table 2 and shown in Figure 2). Determine the final reported (verified) savings values in the context of M&V objectives.

[27] Locally adopted building codes will define gross savings of new construction programs. Only consider standard construction practices of nonparticipant buildings when performing a net-to-gross analysis. One notable exception is when the evaluated program defines its own baseline, according to an above-code standard (for example, ASHRAE Standard 189.1-2011).

Table 2. Comparison of Savings Components for New Construction ECMs

Savings Component	Model Subtraction	Description
Expected Measure Savings	N/A	Energy savings expected by the building designers and/or the DSM program application (also known as the project's planned energy savings).
Rebated Measure Savings	5 – 2	Evaluated (or realized) energy savings for incentivized ECMs, often determined by an independent third-party evaluator. Calculate these savings by subtracting the difference in simulated energy use of the as-built design from the measure building reference (the result is also known as the project's *ex post* savings).
Nonrebated Measure Savings	4 – 5	Energy savings resulting from ECMs implemented in the final building design, but not rebated by the DSM program. Calculate these savings by subtracting the difference in simulated energy use of the measure building reference from the whole-building reference (the result is also known as the spillover savings).
Total Achieved Savings	4 – 2	Evaluated (or realized) energy savings for all implemented ECMs, whether rebated or not. These are often determined using an independent third-party evaluator, and calculated by subtracting the difference in simulated energy use of the as-built design from the whole-building reference. Some DSM programs report this (rather than rebated measure savings) as the project's *ex post* savings.

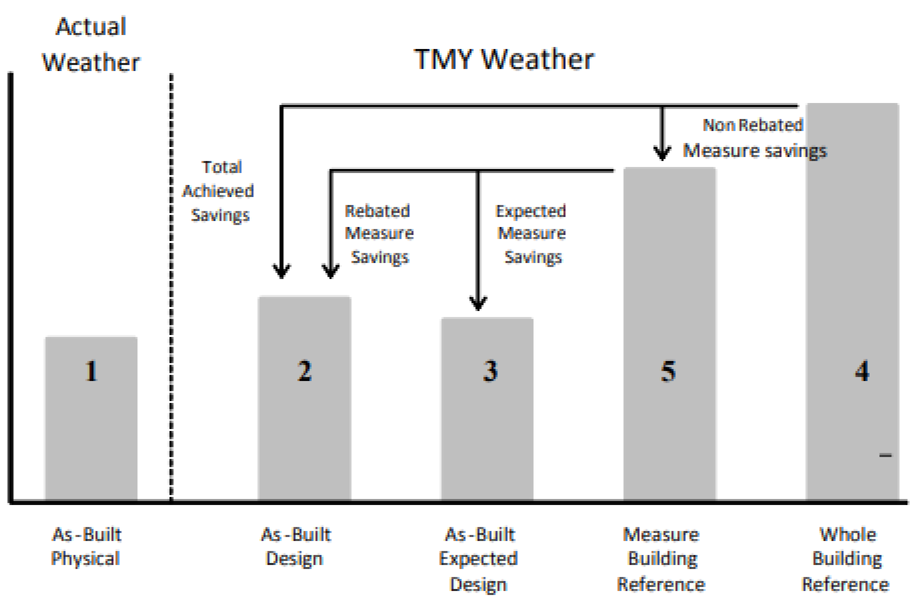

Figure 2. Illustration of savings components for new construction ECMs

B.5.4.5. Quantify and Locate Modeling Uncertainty

Due to the complex set of physical, thermodynamic, and behavioral processes simulated, it is difficult to fully characterize the uncertainty in modeled outputs without multiple statistical and analytical tools. Additionally, practical limitations on budgets and time allotted for M&V activities frequently result in qualifying uncertainty in final simulated savings by reporting uncertainty in the model's calibration to energy consumption history. Quantify calibration uncertainty using the normalized mean bias error (NMBE) and coefficient of variation of the root mean square error (CVRMSE).[28] Pages 13-16 of ASHRAE Guideline 14-2002 (ASHAE 2002), provides detailed descriptions of these calculations and their applications.

Determine calibration uncertainty by comparing outputs from the calibrated as-built physical model with the facility's consumption history. Table 3 shows calibration uncertainty targets for monthly and hourly consumption history resolutions (ASHRAE 2002).

Table 3. Acceptable Tolerances for Uncertainty in Calibrated Building Simulations

Resolution of Energy Consumption History	NMBE Tolerance	CVRSME Tolerance
Monthly	±5%	±15%
Hourly	±10%	±30%

As newly constructed buildings have a short energy consumption history, it is important to consider how many monthly observations are required to attain a suitably calibrated model. The amount of consumption history required for calibration depends on building type and occupancy. Buildings with little seasonal variations in energy use[29] and short ramp-up periods may need as little as three or four months of consumption history, assuming building occupancy and usage are well-defined and stable. Typically, buildings in this category include grocery stores, restaurants, and data centers.

Conversely, buildings that experience significant seasonal variation, or that are not fully occupied for extended periods, may require a complete year (or more) of consumption history before modelers can determine a reliable calibration. For these buildings, occupancy and usage must be well-defined and stable during all observations used for calibration. Typical buildings of this type include offices, schools, and malls (both strip and enclosed).

Mandating definitive requirements for the minimum number of observations required to sufficiently calibrate a simulation would unduly constrain modelers and could place impractical limitations on EM&V efforts. However, this protocol recommends the following as guidelines:

[28] These two statistical measurements provide an assessment of the variance between the simulated and measured (by the utility meter) energy use and electric demand. This protocol considers modeling uncertainty acceptable when this variance is below the thresholds suggested in Table 3

[29] Although energy used by HVAC systems can vary seasonally, such usage generally correlates well with outside weather. Thus, the energy simulation model can sufficiently extrapolate such seasonality (when simulated using the appropriate weather data), reducing the number of billed observations required to calibrate buildings having HVAC use that is dominated by weather.

- Observations should sufficiently characterize a building's energy use, so modelers can extrapolate reliable annual energy-use values.
- Observations should sufficiently describe expected seasonal variations in building operations.
- Building occupancy and operating conditions must be known for the set of observations.
- Building occupancy and operating conditions must remain stable for the duration of observations used for calibration.

While NMBE and CVRSME may prove useful in describing uncertainty in final savings, it is important to minimize the uncertainty in the simulation inputs. These metrics will not completely capture uncertainty in the inputs.

All software packages acceptable for use in Option D require modelers specify a significant number of physical parameters before simulating a building. Often, many of these parameters have default settings in the software package; however, evaluators can base the parameter inputs on experience or standard practices.

Any parameter not directly based on a physical building or its equipment represents a degree of freedom for calibrating the model against a facility's consumption data.[30] By varying these parameters, the modeler can calibrate the same model to meet uncertainty targets in multiple ways, although for very different reasons.

Lack of a unique calibration point can cause misleading results for NMBE and CVRSME. Furthermore, the resultant calibrations respond differently to changes in other parameters, which can lead to significantly divergent savings estimates. Therefore, it is very important modelers minimize calibration uncertainty *and* they accomplish the calibration for the correct reasons. Modelers should not unreasonably alter inputs simply to reduce NMBE or CVRSME.

The following guidelines minimize uncertainty in the calibration process:

- Experienced simulators (or modelers directly supervised by an experienced simulator must perform the modeling.
- Modelers must document each simulation process step, so reviewers can audit the model, its outputs, and its assumptions.
- Simulators and auditors should determine the most influential default model parameters and confirm their appropriateness.
- Simulated equipment (e.g., HVAC coils, chillers, pumps) should not "auto size" in final simulations.[31]

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[30] Each parameter must be constrained by a physically realistic range of values.

[31] When specific data are unavailable, auto-sizing can be helpful in determining appropriate coil capacities, fan speeds, etc. However, only use it for initial equipment sizing. Once equipment sizes have been determined, input them directly. Often, modelers must use auto-sizing to define baseline equipment, as the measures impact building loads. In such cases, calculate an oversize ratio for as-built equipment and apply it to the baseline simulation

- Simulators should identify the parameters to which the simulation outputs are most sensitive.[32]

In addition to quantifying NMBE and CVRSME errors, modelers should analyze the sensitivity of final savings to variations in key model inputs. Modelers should also report such parameters (including their effects on simulated energy savings and the uncertainty in their values) with calibration uncertainty.

B.5.5. Sample Design

Use sampling under the following conditions:

- When performing submetering on building equipment
- When performing a detailed survey of an entire building proves impractical.

Evaluators determine the specific targets for sampling certainty and relative precision in the context of the evaluation. For detailed information regarding sample design and for calculating certainty and precision, see the *Uniform Method Project's Chapter 11: Sample Design Cross-Cutting Protocol.*

B.5.5.1. Sampling for Submetering

Perform submetering to collect information regarding a building's operational schedules. Monitored systems include lighting, ventilation, large equipment (e.g., data centers), and HVAC zone temperatures. Generally, it is acceptable to assume a coefficient of variation (CV) of 0.5 for most submetering; however, while many of these schedules are a function of the overall building type, significant variation in schedules can occur from space to space within a facility. Therefore, interview site personnel to identify any operational differences (and the magnitude of such differences) within the facility before creating a sample design. Account for variations in operating schedules and usage patterns by using a larger CV or by stratifying unique usage groups. See the Uniform Method Project's Metering Cross-Cutting Protocols for additional considerations for commonly monitored equipment.

B.5.5.1.1. Example: Monitoring the Lighting Schedule in a Two-Story Office Building

A two-story commercial office building receives a whole-building performance rebate for LEED certification. For the certification process, a DOE2.2 model is built, for which evaluators develop lighting loads and schedules. During the on-site visit, evaluators note the same tenant occupies both floors, and the building remains open from 6:30 a.m. to 10:00 p.m. The evaluators also identify two unique lighting usage patterns:

[32] Further discussion regarding sensitivity analysis of simulation parameters falls outside this chapter's scope. For additional material on this topic, see Spitler, Fisher, & Zietlow 1989.

- Enclosed offices are located on the building's perimeter
- Open office space is located in the building's core.

As the evaluators identified two distinct usage patterns, they should design the sampling to capture the variability within the schedules for both space types.

- As the open office space is located in the building's core, lighting fixtures likely operate continuously during the building's open hours. Additionally, lighting is commonly shared by all workspaces in the building's core. Therefore, a CV of 0.5 is justified and may prove conservative in determining how many fixtures to monitor.
- Lighting fixtures located in enclosed office spaces typically experience significantly more usage variation due to exaggerated behavioral and external influences. Also, the enclosed office space fixtures receive additional light from perimeter windows, thereby reducing the need for interior lighting during daytime hours. These impacts can be exaggerated (or diminished), depending on fixture control types, building aspects, weather, and times of year. Such additional variability would necessitate a higher assumed CV and additional monitoring points.

B.5.5.2. Sampling for Building Surveys

The on-site data collection encompasses a detailed survey of building systems, such as:

- Lighting fixtures
- Plug loads
- HVAC equipment and controls
- Elevator and auxiliary equipment
- Fenestration
- Envelope constructions.

For many buildings, surveyors can perform a complete walk-through and can install monitoring equipment within a single day. However, larger buildings (such as high-rise office buildings, hotel casinos, and hospitals) present logistical and budgetary complexities that make it impractical (and often impossible) to perform a complete facility walk-through. In these cases, it is permissible to perform a walkthrough of a representative sample of building areas and extrapolate the findings to the rest of the building. Evaluators can apply the findings to individual spaces or to entire floors (the exact sample design depends on the facility design, including any considerations, such as access to space).

B.5.5.2.1. Example: On-Site Audit of a High-Rise Office Building

A 34-story high-rise commercial building located in a major city's downtown region receives a whole-building performance rebate. Various retail businesses rent the first floor, and various tenants use the remaining floors as office space, including a United States Department of Agriculture office. Evaluators collect data during the on-site visit to build a DOE2.2 model; however, the building owner will only provide evaluation personnel access to the building for a single day.

The building is too large to conduct a thorough walk-through in one day. Additionally, it is expected at least one tenant will have areas within its occupied space that evaluators will not be allowed to access. Therefore, evaluators will have to perform sampling for both floors and space types. Evaluators should audit enough floor space to sufficiently characterize internal loads and usage patterns for each tenant and for the building as a whole. The exact number of floors visited will depend on the number of tenants and on the homogeneity between spaces/floors. The evaluators should:

Identify unique operating conditions, such as occupancy schedules, lighting power density (and schedules), and equipment power density (and schedules).

- Identify currently vacant areas (or floors).
- Interview facility staff to:
    - Identify differences in space temperatures or ventilation requirements for each tenant
    - Determine variations in building occupancy (by month or as appropriate) since its opening.
- Audit all central plant equipment.
- Sample air distribution system equipment using sampling criteria described in the Uniform Method Project's *Chapter 11: Sample Design Cross-Cutting Protocol.*

B.5.6. Program Evaluation Elements

These elements differentiate evaluations of new construction programs from those of other programs:

- Evaluators need significantly more resources to define and justify a hypothetical baseline.
- Evaluators have a limited selection of methods for determining site-level savings.
- Buildings rarely operate at a "steady state" at the time of evaluation.

While this is not a comprehensive list, it specifies critical factors that evaluators must consider in developing an evaluation plan—particularly with regard to budget resources for defining and justifying the baselines used to determine energy savings.

Commonly applied codes (such as ASHRAE 90.1) provide multiple compliance pathways, but leave room for local jurisdictions to maintain their own interpretations. Therefore, evaluators should work with local jurisdictions, program implementers, and evaluation managers and oversight agencies to identify the most appropriate baseline for a building. Further, local jurisdictions may adopt an updated building code during implementation of a program, so the evaluator may have to develop baselines from multiple building codes for a given program year.

Given the limited information available to assess new construction ECMs, using calibrated building simulations is often the only option for determining energy savings. Significant planning ensures:

- Evaluators develop detailed M&V plans each project site
- The evaluation allows sufficient time to perform the analyses.

Evaluators often collect additional information using submetering and/or consumption data analysis. As this information is important for model calibration, the M&V plan should allot sufficient time for a thorough analysis of all submetered data and consumption data.

For programs offering incentives, evaluators usually assess energy efficiency measure performance during the first few years of their operation. During this period, building systems and controls typically require troubleshooting,[33] and buildings have low, but growing, occupancy rates.

Evaluators should also keep in mind that owners (or tenants) may use building spaces differently than as originally designed. Thus, the specific codes or standards governing the originally permitted building drawings may not be appropriate for assessing actual energy use or energy savings. This protocol strongly recommends evaluators consider these and other such factors when calibrating models and simulating annual energy savings.

[33] Troubleshooting is formally done through a commissioning process; however, not all buildings are professionally commissioned. In many facilities, facility management must dial in building controls.

B.6. Protocols for Evaluation of Retrocommissioning Projects

B.6.1. Measure Description

Retrocommissioning (RCx) is a systematic process for optimizing energy performance in existing buildings. It specifically focuses on improving the control of energy-using equipment (e.g., heating, ventilation, and air conditioning [HVAC] equipment and lighting) and typically does not involve equipment replacement. Field results have shown proper RCx can achieve energy savings ranging from 5% to 20%, with a typical payback of two years or less (Thorne 2003).[34]

The method presented in this protocol provides direction regarding: (1) how to account for each measure's specific characteristics and (2) how to choose the most appropriate savings verification approach.

A study conducted on behalf of Lawrence Berkeley National Laboratory analyzed data from 11 utilities operating RCx programs across the United States. The dataset included 122 RCx projects and more than 950 RCx measures (PECI 2009). Table B-12 lists a summary of the most common RCx measures, highlighting the nine measures that represent the majority of the analyzed project savings.

Table B-12: Common RCx Measures

RCx Measure	Percentage of Total Savings
Revise control sequence	21%
Reduce equipment size	15%
Optimize airside economizer	12%
Add/optimize supply air temperature reset	8%
Add variable frequency drive to pump	6%
Reduce coil leakage	4%
Reduce/reset duct static pressure set point	4%
Ad/optimize optimum start/stop	3%
Add/optimize condenser water supply temperature reset	2%

As shown in Table B-13 (PECI 2010), RCx measures vary, depending on types of equipment and control mechanisms introduced or optimized. For example, some RCx measures control HVAC equipment according to a predefined schedule, while some measures introduce outdoor air temperature (OAT)-dependent controls.

[34] 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.

Table B-13: Categorization of RCx Measures

Control Mechanism	Equipment Type		
	HVAC Airside	HVAC	Lighting
Scheduled	Matching supply fan schedule to occupancy schedule	Adding/optimizing space setback temperatures	Matching lighting schedule to occupancy schedule
Variable	Optimizing airside economizer	Adding chilled water supply temperature set point reset strategy	Optimizing daylighting control

The classic RCx process helps identify, implement, and maintain improvements to building systems and operations via the following five phases (BPA 2011a).

1. **Planning.** This phase involves screening buildings to determine whether they provide a good fit for RCx by assessing indicators such as equipment age and condition, building energy performance and size, and type of control system. Ideally, facilities should have an existing building automation system (BAS) in good working order, as well as HVAC equipment that is in relatively good condition. A facility without a BAS can install the system; however, the project would then become an HVAC controls and commissioning project rather than an RCx project. When a facility's HVAC equipment nears the end of its useful life, undertaking RCx may not be appropriate because control measures could become obsolete with replaced equipment.
2. **Investigation.** The investigation phase involves analyzing facility performance by reviewing building documentation; performing diagnostic monitoring and functional tests; interviewing staff; identifying a list of recommended improvements; and estimating savings and costs. Evaluators should clearly differentiate valid RCx measures that meet program eligibility guidelines from retrofit measures and/or operation and maintenance (O&M) activities at this phase.
3. **Implementation.** The implementation phase involves prioritizing recommended measures and developing an implementation plan; implementing the measures; and testing to ensure proper operation. Implementation often entails an iterative approach, as the evaluator may need to determine the final control set points through several stages of modification and assessment. These stages ensure building equipment continues to operate properly and maintains the occupants' comfort. Typically, evaluators will review a facility's BAS to assess how effectively RCx measures operate.
4. **Turnover.** The turnover phase involves updating building documentation (e.g., system operation manuals); developing and presenting a final report; and training building operators on proper O&M.

5. **Persistence.** The persistence phase involves monitoring and tracking energy use over time; continually implementing persistence strategies (e.g., refining control measures or enhancing O&M procedures) to sustain savings; and documenting ongoing changes. Depending on the availability of resources and the timeline, program stakeholders may not always actively support this phase.

B.6.2. Application Conditions of Protocol

The RCx program design includes activities intended to overcome a number of market barriers, as listed in Table B-14.

Table B-14: RCx Market Barriers

Market Segment	Barrier	Opportunities
Supply-Side Actors, End Users	No tangible examples of RCx performance in situ	Undertaking pilot opportunities
Supply-Side Actors	Lack of service provider capacity for undertaking the RCx investigation and implementation phases	Training for service providers
End Users	Lack of awareness and understanding of the RCx benefits	Education to increase building owner and operator awareness
End Users	Cost of undertaking RCx	Incentives

Ideally, energy-efficiency programs overcome these barriers through various activities that address available opportunities. Retrocommissioning programs may include some or all of the following activities:

Pilot projects. Program administrators sometimes fund pilot projects to demonstrate the benefits of RCx to end users in their target markets. Evaluators can verify pilot savings using the methods presented later in this protocol and, in theory, these savings will attract participants to the program.

Training. Program administrators sometimes fund or develop training for service providers. In some jurisdictions, service providers do not routinely provide RCx services to their customer base. Thus, to develop RCx capacity in the market, program administrators might offer training to service providers on how to provide common practice RCx investigation and implementation services. Service providers may also require training on how to sell these services to their clients.

Education. Program administrators sometimes develop educational materials and hold events or workshops for end users. Prior to making a decision to undertake RCx activities in their facilities, building management and building operators need to understand the business case for RCx. Detailed case studies showcasing project savings are an example of education tools program staff can use to facilitate this decision-making process.

Incentives. Program administrators often provide incentives to undertake the RCx investigation, implementation, and persistence phases. Even though the payback for RCx measures is typically low, end users often require incentives to encourage them to move forward with projects.[35] Incentives may also encourage end users to undertake projects sooner—or with a greater scope—than they would have without market intervention.

This protocol provides structured methods for determining energy savings resulting from the implementation of RCx measures. The approaches described here provide direction on how to verify savings consistently from pilot projects, as well as from projects implemented by program participants. It does not address savings achieved through training or through market transformation activities.

B.6.3. Savings Calculations

Specific savings calculations[36] for RCx measures inherently vary, due to the breadth of possible RCx measures, which can differ by type of equipment or control mechanism. This section presents a high-level gross energy savings equation that is applicable to all RCx measures. Section 4, *Measurement and Verification Plan*, includes detailed directions for calculating savings for specific measure categories.

Use the following general equation (EVO 2012) to determine energy savings:

Equation 1

$$Energy\ Savings = (Baseline\ Energy - Reporting\ Period\ Energy) \pm\ Routine\ Adjustments \pm\ Nonroutine\ Adjustments$$

Where:

$Energy\ Savings =$ First-year energy consumption savings

$Baseline\ Savings =$ Preimplementation consumption

$Reporting\ Period\ Savings =$ Postimplementation consumption

$Routine\ Adjustments =$ Adjustments made to account for routinely changing independent variables (variables that drive energy consumption). If applicable, normalize savings to typical

[35] Some programs may impose a penalty rather than an incentive. For example, if participants fail to implement the measures that fell below a certain payback threshold identified during the investigation phase, they may not be eligible for the full investigation phase incentive.

[36] As presented in the Introduction, the protocols focus on gross energy savings and do not include other parameter assessments, such as net-to-gross, peak coincidence factors, or cost-effectiveness

meteorological year (TMY[37]) weather data, as well as other significant independent variables (e.g., occupancy, production data).

$Nonroutine\ Adjustments =$ Adjustments made to account for parameters typically not expected to change during the implementation period. Account for these parameters if they change *and* this change influences the reporting period energy use (e.g., changes to a facility's building envelope during implementation of and RCx HVAC measure). Evaluators only need to consider nonroutine adjustments if verifying savings using Option C of the International Performance Measurement and Verification Protocol (IPMVP).[38]

Determining RCx demand savings is not a straightforward extension of verified consumption savings (unlike lighting retrofits, where evaluators can easily apply established load savings profiles to consumption savings data). For RCx projects, load savings profiles vary depending on the type of measures implemented and the distribution of these measures. If applicable, evaluators should produce load savings profiles on a measure-by-measure basis,[39] aggregate these profiles, and then apply site-specific coincidence factors to determine coincident peak demand savings at the project level.

B.6.4. Measurement and Verification Plan

This section outlines the recommended approaches to determining RCx energy savings and provides directions on how to use the approaches under the following headings:

- Measurement and verification (M&V) method
- Data collection
- Interactive effects
- Specific savings equations
- Regression model direction
- Deemed spreadsheet tool functionality requirements

[37] Evaluators should use the most recent typical meteorological year dataset. As of January 2014, the most comprehensive national typical meteorological year dataset is TMY3. Evaluators should confer with the local jurisdiction to see if they should use a different regional dataset.

[38] 5 Option C is the "whole-facility approach" to verifying savings

[39] Alternatively, if verifying savings by following Option C or D of the IPMVP, evaluators can measure or compute aggregate project-level load savings profile and negate the requirement to build up the profile on a measure-by measure basis. If using Option C, evaluators should investigate whether data from advanced metering infrastructure (e.g., interval meters) is available to increase the accuracy of billing data analyses.

B.6.4.1. Measurement and Verification Method

There is a structured method for determining the most appropriate approach to verifying RCx energy savings. This method balances the need for accurate energy-savings estimates with the need to keep M&V costs in check, relative to project costs and anticipated energy savings. Depending on which measures are implemented, different approaches to estimating the savings are appropriate. Following the IPMVP, the options are:

- Option A—Retrofit Isolation: Key Parameter Measurement
- Option B—Retrofit Isolation: All Parameter Measurement
- Option C—Whole Facility
- Option D—Calibrated Simulation

Measurement is inherent with most RCx projects because RCx measures typically involve modifications made through a facility's BAS. As mentioned, RCx implementation (an iterative process) often leverages metered data to evaluate and optimize changes throughout the process. Therefore, in many cases, a retrofit isolation approach adhering to Option A or Option B of the IPMVP proves most logical. That said, scenarios exist where Option C, Option D, or even a deemed approach may be more appropriate. Figure 7 presents a decision flow chart for determining the approaches to follow.

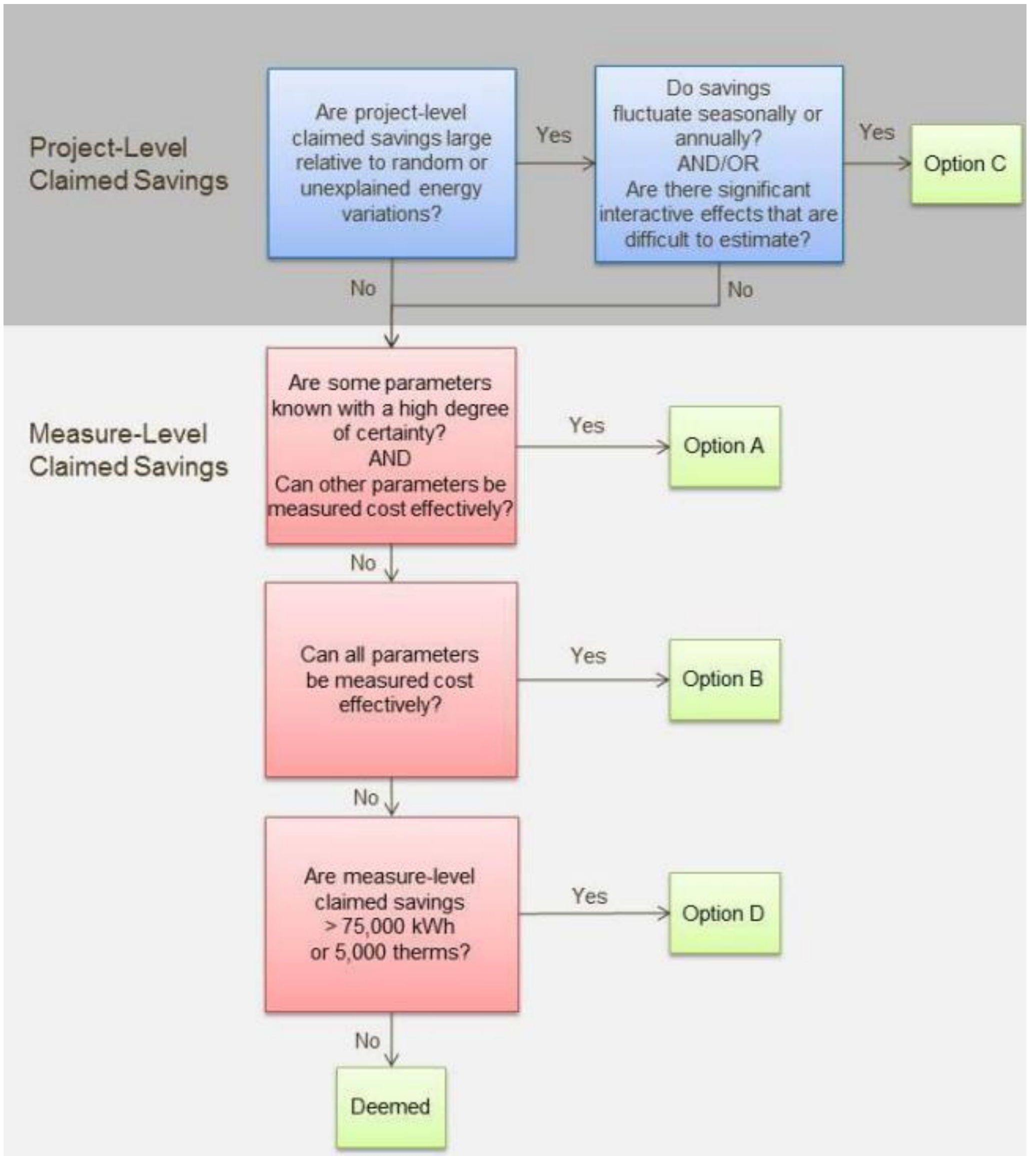

Figure 7: RCx approach-decision flow chart

The decision flow chart accounts for factors such as the magnitude of estimated savings and the measurement's cost-effectiveness. Begin the process by considering project-level savings:

- **Option C.** Use a whole-facility approach—adhering with Option C of the IPMVP—if estimated project-level savings are large compared to the random or unexplained energy variations that occur at the whole-facility level[40] and if savings fluctuate over a seasonal or annual cycle (e.g., savings that fluctuate depending on OAT). This

[40] Typically savings should exceed 10% of the baseline energy for a particular meter (e.g., electricity meter) to confidently discriminate the savings from the baseline data when the reporting period is shorter than two years (EVO 2012).

approach is likely the most cost-effective approach for verifying savings. The whole-facility approach is relatively inexpensive because evaluators can use utility billing data for the analysis. The downside of the approach is that evaluators cannot perform verification until after collecting a full season or year of reporting period data and monitoring and documenting any changes to the facility's static factors[41] over the course of the measurement period. Even if savings remain consistent month to month, Option C may provide the best approach if project measures cause complex, significant interactive effects. Such interactive effects are, by nature, difficult to estimate accurately. Also, if the effects are significant (large, relative to direct-measure savings), evaluators will be required to use a whole-facility approach to measure impacts accurately. The reduced heating and cooling energy resulting from schedule changes to an air-handling unit, when control modifications have also been undertaken for both the heating and cooling systems, is an example of a complex significant interactive effect warranting Option C.

If Option C is ruled out, consider performing verification on a measure-by-measure basis:

- Option A. If measures involve some parameters known with a high degree of certainty and other parameters can be measured cost-effectively, use a retrofit isolation approach adhering to Option A of the IPMVP. In many cases, evaluators can collect metered data directly from the facility's BAS. If required, the facility can add control points to the BAS, either as part of the implementation process or specifically for M&V purposes. Where the BAS cannot provide the information, use temporary meters to collect data (provided that costs are not prohibitive).
- Option B. If a given measure's parameters are uncertain but can be measured costeffectively, use a retrofit isolation approach, adhering to Option B of the IPMVP. Again, collect metered data (similar to Option A) either through the BAS or by using temporary meters.
- Option D. For measures where it is prohibitive to meter all required parameters, use a calibrated simulation approach adhering to Option D of the IPMVP. Undertake calibrations in two ways: (1) calibrate the simulation to the actual

[41] Many factors can affect a facility's energy consumption, even though evaluators do not expect them to change. These factors are known as "static factors" and include the complete collection of facility parameters that are generally expected to remain constant between the baseline and reporting periods. Examples include: building envelope insulation, space use within a facility, and facility square footage

baseline or reporting consumption data and (2) confirm the reporting period inputs via the BAS front-end system, when possible.[42],[43]

- Deemed. Finally, if a measure is relatively common[44] and its estimated savings are small, evaluators can deem savings rather than simulate them. Use this approach for common measures with savings less than 75,000 kilowatt-hours (kWhs) or 5,000 therms[45] (PECI 2010). Use a spreadsheet tool to calculate savings, adhering to functionality requirements presented later in the protocol.

B.6.4.2. Data Collection

Depending on the approach followed, these M&V elements will require particular consideration:

- The measurement boundary
- The measurement period and frequency
- The functionality of measurement equipment being used
- The savings uncertainty.

B.6.4.2.1. Measurement Boundary

For measures evaluators assess using Option A or Option B and that require metering external to the BAS, it will be important to define the measurement boundary. When determining boundaries—the location and number of measurement points required—consider the project's complexity and expected savings:

- While a narrow boundary simplifies data measurement (e.g., a single piece of equipment), variables driving energy use outside the boundary (i.e., interactive effects) still need to be considered.
- A wide boundary will minimize interactive effects and increase accuracy (e.g., systems of equipment like chilled water plants and air-handling units). However, as M&V costs may also increase, it is important to ensure the expected project savings justify the increased M&V costs.

B.6.4.2.2. Measurement Period and Frequency

For all measures assessed with Option A or Option B, consider two important timing metrics:

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[42] In many cases, the simulation should represent the entire facility; however, in some cases, depending on the facility's wiring structure, a similar approach could be applied to building submeters, such as distribution panels that include the affected systems.

[43] See the Uniform Method Project's Commercial New Construction Protocol for more information on using Option D.

[44] If regulators are involved, going through the effort of deeming savings for a rare measure can be burdensome.

[45] Program administrators and evaluators may wish to customize these thresholds for particular programs and/or jurisdictions.

- The measurement period (the length of the baseline and reporting periods)
- The measurement frequency (how regularly to take measurements during the measurement period).

As a general rule, choose the measurement period to capture a full cycle of each operating mode. For example, if there is a control modification to heating equipment, collect data over the winter and shoulder seasons.

Choose the measurement frequency by assessing the type of load measured:

- Spot measurement: For constant loads, measure power briefly, preferably over two or more intervals. • Short-term measurement: For loads predictably influenced by independent variables (e.g., HVAC equipment influenced by OAT), take short-term consumption measurements over the fullest range of possible independent variable conditions, given M&V project cost and time limitations.[46] For systems expected to have nonlinear dependence (such as airhandling units with outside air economizers), measurements should incorporate sufficient range to characterize the full breadth of conditions.
- Continuous measurement: For variable loads, measure consumption data continuously, or at appropriate discrete intervals, over the entire measurement period.

See Section 4.4, *Specific Saving Equations*, for direction regarding measurement periods and frequency for specific measure types.

B.6.4.2.3. Measurement Equipment

When meters external to the BAS are required, follow these guidelines to select a meter:[47]

- Size the meter for the range of values expected most of the time.
- Select the meter repeatability and accuracy that fits the budget and intended use of the data.
- Install the meter as recommended by the manufacturer.
- Calibrate the meter before it goes into the field, and maintain calibration as recommended by the manufacturer. If possible, select a meter with a recommended calibration interval that is longer than the anticipated measurement period.

[46] For example, if a chiller plant undergoes control modifications, the measurement frequency should be long enough to capture the full OAT operating range. In a temperate climate zone, evaluators can accomplish this by taking measurements over a four-week period in the shoulder season and another four-week period during the summer season.

[47] For more information on selecting measurement equipment, see the Uniform Methods Project's Metering CrossCutting Protocols.

If BAS data is used, evaluators should exercise due diligence by determining when the BAS was last calibrated and by checking the accuracy of the BAS measurement points.

B.6.4.2.4. Savings Uncertainty

If possible, quantify the accuracy of measured data[48] and, if practical, conduct an error propagation analysis to determine overall impacts on the savings estimate.

B.6.4.3. Interactive Effects

For projects following Option A, Option B, or deemed approaches, consider and estimate interactive effects if they are significant. For example, if a facility reduces an air-handling unit supply fan schedule, not only will direct fan savings be achieved, but significant cooling and heating energy savings may be realized due to decreases in conditioned ventilation air supplied to the space. Estimate interactive effects using equations that apply the appropriate engineering principles. Ideally, use a spreadsheet tool adhering to the same functionality requirements discussed in Section 4.6 for the deemed spreadsheet tool to conduct these analyses. When interactive effects are large, it may be possible to measure them rather than apply engineering estimates. In the "supply fan" example discussed in the paragraph above, an evaluator can meter the chilled water plant to determine the cooling load reduction.

Interactive effects for projects being verified using Option C or Option D are typically included in facility-level savings estimates.

B.6.4.4. Specific Savings Equations

If following Option A or Option B, verify savings using equations matching a given measure's characteristics—specifically, whether savings are dependent on independent variables (such as OAT) and the control mechanism for affected equipment.

Figure 8 shows the three categories of savings equations, with further explanations following the flow chart.

[48] Metering accuracy is only one element of savings uncertainty. Inaccuracies also result from modeling, sampling, interactive effects, estimated parameters, data loss, and measurements being taken outside of a meter's intended range.

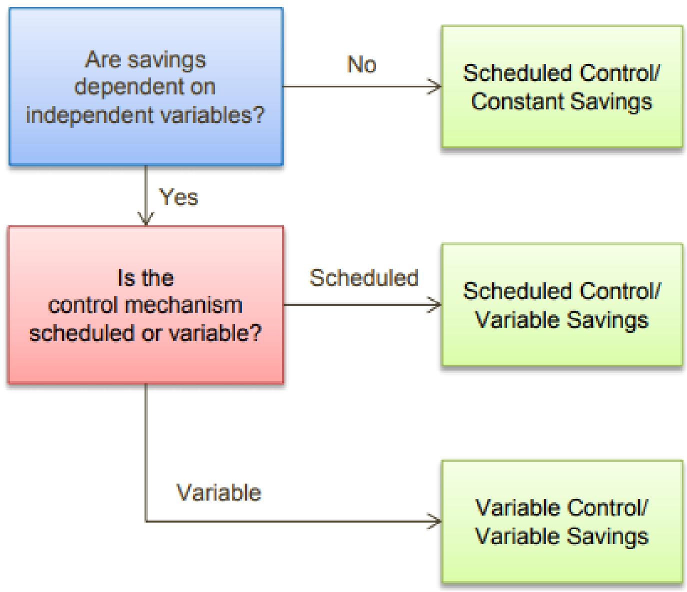

Figure 8: Savings equation categories

B.6.4.4.1. Scheduled Control/Constant Savings

This savings equation category encompasses scheduled control measures on equipment not influenced by independent variables (such as OAT); therefore, this is the most straightforward equation category.

Lighting schedule optimization is an example of a measure verified using this savings equation category. In this example, lighting is turned off according to a schedule (scheduled control), and constant savings is achieved while it is off (constant savings).[49]

Equation 2

$$Scheduled\ Control/Savings = Baseline\ Energy\ - ReportingPeriod\ Energy$$

Where:

$Scheduled\ Control/Savings =$ First-year energy consumption savings resulting from a scheduled control measure with constant savings.

$Baseline\ Energy =$ $HRS_{baseline}$ x $kW_{controlled}$

$Reporting\ Period\ Energy =$ $HRS_{reporting}$ x $kW_{controlled}$

[49] While a single piece of equipment (one lighting fixture) may have a constant load, the system (lighting throughout a building) may have some variability. In a lighting system that includes a degree of occupant control (such as switches in private offices) nearly 100% of fixtures may operate midday, but substantially fewer may be on at the beginning or end of the day when the savings due to scheduling would likely occur.

And,

$HRS_{baseline}$ = Annual operating hours during the baseline: if this parameter is not known with a high degree of certainty, take short-term measurements for the duration of each existing schedule type

$HRS_{reporting}$ = Annual operating hours during the reporting period: take short-term measurements for the duration of each new schedule type.

$kW_{controlled}$ = Electric demand controlled by scheduling measure: if this parameter is not known with a high degree of certainty, take spot measurements during the baseline or reporting period.

B.6.4.4.2. Scheduled Control/Variable Savings

This savings equation category encompasses scheduled control measures on equipment influenced by independent variables (such as OAT). Space setback temperature optimization provides an example of a measure verified using this savings equation category. In this example, the heating space temperature set point is lowered according to a schedule during unoccupied hours (scheduled control), and the savings achieved will vary, depending on OAT (variable savings).

Following Equation 3, Table B-15 lists the five-step process for determining adjusted baseline and reporting period energy consumption.

Equation 3

$$Scheduled\ Control/Variable\ Savings$$
$$= Baseline\ Energy\ - Adjusted\ Reporting\ Period\ Energy$$

Where:

$Scheduled\ Control/Variable\ Savings$ = First-year energy consumption savings resulting from a scheduled control measure with variable savings.

$Adjusted\ Baseline\ Energy =$ $\sum_{All\ Schedule\ Types} Adj\ Baseline\ Consumption_{Schedule\ Type}$ and determined through the five-step process listed in Table B-16.

$Adjusted\ Reporting\ Period\ Energy =$ $\sum_{All\ Schedule\ Types} Adj\ Reporting\ Period\ Consumption_{Schedule\ Type}$ and determined through the five-step process listed in Table B-16.

Table B-15: Adjusted Consumption for Scheduled Control/Variable Savings Measures

<table>
<tr><th>Step</th><th colspan="3">Details</th></tr>
<tr><td>Develop baseline/reporting regression model(s) by measuring equipment operation and independent variables.</td><td colspan="3">Take short-term measurements at representative load levels for the affected equipment for each schedule type.

Take coincident measurements of the independent variable(s).

Do a regression analysis to determine the relationship between independent variables and equipment load. This relationship should be expressed in terms of an equation (baseline/reporting period model).

Note: if there are schedules for occupied and unoccupied times during the reporting period, evaluators will need two regression models, one for each set of data.</td></tr>
<tr><td rowspan="3">Develop a bin operating profile[a] by normalized independent variable data.</td><td colspan="3">Develop bin data tables presenting the following data (one table for each schedule type):</td></tr>
<tr><td>Independent Variable</td><td>Load</td><td>Annual Hours</td></tr>
<tr><td>Create approximately 10 bins over the normalized independent variable data range (if the equipment's energy consumption varies depending on weather, use TMY data).</td><td>Calculate the normalized load by applying the baseline/reporting period regression model to the midpoint of each bin.</td><td>Use short-term measured data to estimate hours of operation within each bin or base this on TMY data and the equipment operating schedule.</td></tr>
<tr><td>Calculate the baseline/reporting period consumption at each load bin for each schedule type.</td><td colspan="3">$\text{Adjusted Consumption}_{\text{Load,Schedule Type}} = \text{Load}_{\text{Schedule Type}} \times \text{Annual Hrs}_{\text{Schedule Type}}$</td></tr>
<tr><td>Sum the consumption savings across bins for each schedule type.</td><td colspan="3">$\sum_{All\ Load\ Bins_{Schedule\ Type}} Adj\ Consumption_{Load,Schedule\ Type}$</td></tr>
<tr><td>Sum the consumption savings across schedule types.</td><td colspan="3">$\sum_{All\ Schedule\ Types} Adj\ Consumption_{Schedule\ Type}$</td></tr>
</table>

[a] Alternatively, if the independent variable is OAT, evaluators can develop an hourly profile over the full operating schedule of the affected equipment.

B.6.4.4.3. Variable Control/Variable Savings

This savings equation category encompasses variable control measures on equipment influenced by independent variables, such as OAT. Introducing a chilled water supply temperature set point reset strategy serves as an example of a measure verified through this savings equation category. In this example, the chilled water supply temperature set point is determined depending on OAT (variable control), and the savings achieved will vary depending on OAT (variable savings).

Following Equation 4, Table B-16 lists the four-step process for determining the adjusted baseline and reporting period energy consumption.

Equation 4

$$Variable\ Control/Variable\ Savings$$
$$= Adjusted\ Baseline\ Energy\ - Adjusted\ Reporting\ Period\ Energy$$

Where:

$Variable\ Control/Variable\ Savings =$ First-year energy consumption savings resulting from a variable control measure with variable savings.

$Adjusted\ Baseline\ Energy = \sum_{All\ Load\ Bons} Adj\ Baseline\ Consumption_{Load}$ and determined through the five-step process listed in Table B-16.

$Adjusted\ Reporting\ Period\ Energy =$ $\sum_{All\ Load\ Bins} Adj\ Reporting\ Period\ Consumption_{Load}$ and determined through the five-step process listed in Table B-16.

Table B-16: Adjusted Consumption for Variable Control/Variable Savings Measures

<table>
<tr><th>Step</th><th colspan="3">Details</th></tr>
<tr><td>Develop baseline/ reporting regression model(s) by measuring equipment operation and independent variables.</td><td colspan="3">Take short-term measurements at representative load levels for the affected equipment for each schedule type.

Take coincident measurements of the independent variable(s).

Do a regression analysis to determine the relationship between independent variables and equipment load. This relationship should be expressed in terms of an equation (baseline/reporting period model).</td></tr>
<tr><td rowspan="3">Develop a bin operating profile[a] by normalized independent variable data.</td><td colspan="3">Develop bin data tables presenting the following data:</td></tr>
<tr><td>Independent Variable</td><td>Load</td><td>Annual Hours</td></tr>
<tr><td>Create approximately 10 bins over the normalized independent variable data range (e.g., if the equipment's energy consumption varies depending on weather, use TMY data).</td><td>Calculate the normalized load by applying the baseline/reporting period regression model to the midpoint of each bin.</td><td>Use short-term measured data to estimate hours of operation within each bin, or base this on TMY data and the equipment operating schedule.</td></tr>
<tr><td>Calculate the baseline/reporting period consumption at each load bin.</td><td colspan="3">Adjust Consumption
$\text{Adj Consumption}_{Load}$ = Load x Annual Hours</td></tr>
<tr><td>Sum the consumption savings across bins.</td><td colspan="3">$\sum_{All\ Load\ Bins} Adj\ Consumption_{Load}$</td></tr>
</table>

[a] Alternatively, if the independent variable is OAT, evaluators can develop an hourly profile over the full operating schedule of the affected equipment.

B.6.4.5. Regression Modeling Direction

Calculating normalized savings for the majority of projects—whether following the IPMVP's Option A, Option B, or Option C— will require the development of a baseline and reporting period regression model.[50] Use one of the following three types of analysis methods to create the model:

- *Linear Regression:* For one routinely varying significant parameter (e.g., OAT).[51]
- *Multivariable Linear Regression:* For more than one routinely varying significant parameter (e.g., OAT, occupancy).

[50] This could either be a single regression model that uses a dummy variable to differentiate the baseline/reporting period data or two independent models for the baseline and reporting period, respectively.

[51] One of the most common linear regression models is the three-parameter change point model. For example, a model that represents cooling electricity consumption will have one regression coefficient that describes nonweather-dependent electricity use, a second regression coefficient that describes the rate of increase of electricity use with increasing temperature, and a third parameter that describes the change point temperature, also known as the balance point temperature, where weather-dependent electricity use begins.

- *Advanced Regression:* For a multivariable, nonlinear fit requiring a polynomial or exponential model.[52]

Develop all models in accordance with best practices and only use them when they are statistically valid (see Subsection B.6.4.5.2, *Testing Model Validity).* If no significant independent variables arise (as with a lighting schedule measure), evaluators are not required to use a model because calculated savings will be inherently normalized.

B.6.4.5.1. Recommended Methods for Model Development

Use energy and independent variable data that is representative of a full cycle of operation. For example, if facility staff implement a heating space temperature setback measure, collect energy data across the full range of OAT for each of the operating schedules (occupied and unoccupied) for each season, as shown in Table B-17.

Table B-17: Example of Data Required for Model Development

	Shoulder Season	Winter Season
Occupied Hours	Short-term energy measurements during occupied hours. Measurements should be representative of the full range of shoulder season OAT (approximately 10 OAT bins).	Short-term energy measurements during occupied hours. Measurements should be representative of the full range of winter-season OAT (approximately 10 OAT bins).
Unoccupied Hours	Short-term energy measurements during unoccupied hours. Measurements should be representative of the full range of shoulder-season OAT (approximately 10 OAT bins).	Short-term energy measurements during unoccupied hours. Measurements should be representative of the full range of winter-season OAT (approximately 10 OAT bins).

Analyze the data collected to identify outliers. Only remove outliers when there is a tangible explanation to support the erratic data points. Discussion of how to identify outliers is outside the scope of this protocol.

B.6.4.5.2. Testing Model Validity

To assess the model's accuracy, begin by reviewing the parameters in Table B-18 (EVO 2012).

[52] Evaluators may need to use advanced regression methods if RCx activities impact manufacturing or industrial process equipment.

Table B-18: Model Statistical Validity Guide

Parameter Evaluated	Description	Suggested Acceptable Values
Coefficient of determination (R^2)	A measure of the extent that the regression model explains variations in the dependent variable from its mean value.	> 0.75
T-statistic (absolute value)	An indication of whether regression model coefficients are statistically significant.	> 2a[a]
Mean bias error	An indication of whether the regression model overstates or understates actual energy consumption.	Will depend on the measure, but generally: < ±5%

[a] Determine the t-statistic threshold based on the evaluator's chosen confidence level; a 95% confidence level requires a t-statistic of 1.96. Evaluators should determine an acceptable confidence level depending on project risk (i.e., savings risk), budget, and other considerations.

A model outside the suggested range indicates parameter coefficients that are relatively poorly determined, with the result that normalized consumption will have relatively high statistical prediction error. Ordinarily, evaluators should not use such a model for normalization, unless the analysis includes appropriate statistical treatment of this prediction error. Discussion of how to proceed in such circumstances is outside the scope of this protocol.

When possible, attempt to enhance the regression model by:

- Increasing or shifting the measurement period
- Incorporating more data points
- Including independent variables previously unidentified
- Eliminating statistically insignificant independent variables.

Also, when assessing model validity, consider coefficient of variation of the root mean squared error, fractional savings uncertainty, and residual plots. Refer to ASHRAE Guideline 14-2002 and Bonneville Power Administration's *Regression for M&V: Reference Guide* for direction on how to assess these additional parameters.

B.6.4.6. Deemed Spreadsheet Tool Functionality Requirements

When collecting measured energy data is not cost-effective and claimed (*ex ante*) savings estimates for a given measure are sufficiently small (75,000 kWh or 5,000 therms), use a deemed approach to calculate savings. In this scenario, the protocol recommends using a spreadsheet tool to calculate savings, and this tool should meet these general requirements:

Ensure model transparency. A third party should be able to review the spreadsheet tool and clearly understand how the evaluator derived all savings outputs. To this end, clearly explain and reference all inputs and calculation algorithms within the spreadsheet. Do not lock or hide cells or sheets and check to ensure all links work properly.

Use relevant secondary data. When using secondary data as inputs to savings algorithms, ensure they are relevant to the project's region or jurisdiction. Substantiate input relevancy within the spreadsheet. For example, if using assumed values for hours of operation for heating equipment, take these secondary data from a regional resource (e.g., a technical resource manual from the most applicable demand-side management authority).

Verify input elements—either on site or through the BAS front-end system. Even when using a deemed approach, verify and update some inputs with actual site observations (rather than solely relying on secondary data). For example, confirm a new lighting schedule through the BAS front-end system and note it in the spreadsheet tool.

Establish default values for unverifiable parameters. Use default values for parameters that cannot be verified. For example, clearly state assumed values for motor efficiencies and load factors.

The Building Optimization Analysis Tool,20 developed by Portland Energy Conservation Inc., (PECI 2010) provides an example of benchmark for RCx spreadsheet tools. Although the protocol does not require the following level of rigor, ideally, a best-practice spreadsheet tool should:

- Incorporate regional TMY data.
- Incorporate regional building archetype templates.
- Undergo a calibration process by using measured data from previous regional projects to test algorithms.

B.6.5. Sample Design

Consult the Uniform Methods Project's Sample Design Cross-Cutting Protocols for general sampling procedures if the RCx program project population is sufficiently large or if the evaluation budget is constrained. Ideally, use stratified sampling to partition RCx projects by measure type, facility type, and/or project size. Stratification ensures evaluators can confidently extrapolate sample findings to the remaining project population. Regulatory or program administrator specifications typically govern the confidence and precision-level targets that influence sample size.

B.6.6. Other Evaluation Issues

When claiming lifetime and net program RCx impacts, evaluators should consider persistence and net-to-gross in addition to first-year gross impact findings.

B.6.6.1. Persistence

Persistence of savings encompasses both the retention and the performance degradation of measures. Evaluators should consider persistence on a program-by-program basis because the persistence of RCx projects can vary widely depending on the distribution of measure types implemented and, perhaps more significantly, on how well facility staff maintains the modifications. Consult the Uniform Methods Project's *Assessing Persistence and Other Evaluation Issues Cross-Cutting Protocols* for more information.

B.6.6.1.1. Estimating Effective Useful Life (EUL) from Savings Persistence in RCx Projects

For cases where unable to determine measure persistence, the TPE has conducted an analysis of persistence for common measure types in RCx projects and extrapolated EULs suitable for cost-benefit analysis. The analysis was based on findings from a field study of persistence in RCx projects, prepared 2018 by Seventhwave on behalf of ComEd.[53]

B.6.6.1.1.1. Methodology

The TPE calculated effective useful life (EUL) for a group of measures using savings persistence estimates. The savings persistence estimates were calculated relative to a baseline program year when measures were implemented. As such, they represent both measure life and savings persistence. In particular, savings persistence accounts for changes in equipment life (the amount of time before equipment fails), measure persistence (i.e. equipment failure or business turnover), and true savings persistence as defined by the UMP[54] (i.e. changes in operating hours, process operations, or performance degradation of the equipment relative to the baseline option).

Savings persistence values were obtained for each measure at various dates following measure installation (e.g. every three years). Savings persistence in years not measured was interpolated between years in which saving persistence was known. This creates a step-like function with different slopes for each measured interval. For years that exceed the last measured persistence, the TPE extrapolated persistence using the slope from the prior measured interval. The EUL was capped at 7 years to account for a lack of savings persistence estimates after year 6.

The equation below shows how the EUL for each measure was calculated from the predicted savings persistence values.

$$Effective\ Useful\ Life = \sum_{t=0}^{n} Savings\ Persistence_t$$

[53] https://slipstreaminc.org/sites/default/files/documents/publications/retrocommissioning-persistence-studyfinal-reportoct-2018.pdf

[54] https://www.energy.gov/sites/prod/files/2013/05/f0/53827-13.pdf

B.6.6.1.1.1. Resulting EULs

Measure Type	*EUL Capped (yr 7)*[55]
Air distribution	4.00
Plant optimization	5.00
Ventilation	5.00
Scheduling	5.50
Filters	5.50
General	5.50

B.6.6.2. Net to Gross

Consult the Uniform Methods Project's *Estimating Net Energy Savings: Common Practices* for a discussion about determining net program impacts at a general level, including direction on how to assess freeridership. Supplementary to that chapter, however, evaluators may consider assessing participant spillover if evidence emerges of participants implementing no-cost measures. This would specifically apply to no-cost measures identified during the investigation phase, but not explicitly included under the scope of program-funded RCx implementation activities.

If no-cost measures exist and there are no savings claims, the attribution evaluation may involve interviews with building operators and their service providers to obtain estimates of the savings magnitude resulting from these measures. Participant spillover would positively influence the program's overall net-to-gross factor.

[55] For ease of use, these have been rounded to the nearest half year.

B.7. Protocols and Guidance for Establishing Quality Assurance / Quality Control for Programs

Continuous improvement in the operation of energy efficiency and demand response programs requires that procedures for quality assurance and quality control be put in place and applied continuously in real time.

- With Quality Assurance (QA), standards to promote consistency and minimize errors are developed and applied during the planning and design of a program.
- Quality Control (QC) activities are conducted continuously in real time to ensure that programs are being implemented and operated according to set quality standards.

B.7.1.1. QA/QC Protocol 1: Approach to Quality Assurance

Quality Assurance activities occur throughout a program's lifecycle to ensure that program processes are aligned with objectives, that risk is avoided, and that efficiency is being promoted. QA activities are used to ensure that program rules and requirements are documented and current, that participating contractors and trade allies are properly licensed and trained and maintain high quality standards in interactions with customers, and that data are accurate and sufficient for analyzing energy savings analysis.

Examples of QA activities include the following:

- Developing program logic models and process maps that document the goals, processes, and expected outcomes associated with key activities in each program;
- Implementing training protocols that describe training procedures and requirements for key program stakeholders, such as CSPs and trade allies;
- Applying rigorous screening and qualifying protocols to CSPs, trade allies, and field staff that interact directly with customers;
- Documenting data collection protocols, including data and customer information needed to track activities and calculate savings for each program; and
- Summarizing CSPs' gross energy savings calculation methods that are reported at the measure or project level to support consistency and accuracy across programs.

Information on processes used with a program can be organized through preparation of a "program logic model"[56]. In broadest terms, a logic model shows how resources are used in activities to produce outputs that yield outcomes. The logic model for a program should provide a clear description of the processes used with that program to provide energy efficiency services and / or products to customers participating in the program. Essentially, developing the logic model should show what the processes for a program are supposed to do, with *whom* and *why*. In particular, the program logic model should:

[56] McLaughlin, J.A., & Jordan, G.B. (2004). Using logic models. In J.S. Wholey, H.P. Hatry, & K.E Newcomber (Eds.), *Handbook of practical program evaluation* (2nd ed., pp. 7-32). Hoboken, NJ: John Wiley & Sons.

- Identify the group(s) involved with the program;
- Identify the resources being allocated to the program;
- Describe those activities or action steps that are being used to achieve outcomes;
- Define the outcomes or objectives for a program, where outcomes are those changes or benefits that result from activities; and
- Determine whether the objectives are being achieved.

While a program logic model shows the structure and practices desired and expected for a program, quality assurance procedures are used to identify and identify standards that eliminate variations or defects in program processes that may cause appropriate quality to not be achieved. A framework for assuring that quality requirements are being met is provided by the Plan-Do-Check-Act cycle paradigm that was popularized by Deming and that is the basis for ISO 9001: 2015, the international standard that specifies requirements for a quality management system. As summarized in Table B-19, the PDCA cycle provides a four-step method for continuous quality improvement.

Table B-19: Steps in PDCA Cycle for Quality Assurance

Step	***Activity***
Plan	Establish objectives for quality and determine processes or changes in processes that are required to deliver desired quality. Determine specific levels of quality or measurable results to be achieved
Do	Develop and test process and / or changes in processes.
Check	Monitor and evaluate processes or changes to determine whether quality is meeting predetermined objectives. To extent possible, use objective measurements or tests to determine whether quality goals are being met, rather than using subjective evaluation of quality.
Act	Implement actions that are necessary to achieve desired improvements in quality
If appropriate, repeat, beginning with new objectives being planned.	

Guidance on using the ISO 9001: 2015 standard and the PDCA cycle to develop and implement an effective quality assurance and management system can be found in a handbook published in 2016 by the International Standards Organization:

ISO 9001: 2015 for Small Enterprises: What to do?

(Available for purchase at https://www.iso.org/publication/PUB100406.html.)

B.7.1.2. QA/QC Protocol 2: Procedures for Quality Control

Quality control procedures should be applied continuously in real time to ensure that program activities adhere to the standards set through the QA work and conform to performance expectations at the program and portfolio levels. QC activities address operational procedures, data and records, and measure installation. Examples of QC procedures include the following:

- Ongoing tracking of program activities and costs.

- Reviewing all data and records to confirm that the proper data are collected consistently, resources are allocated appropriately, and program performance can be measured accurately.
- Conducting follow-up calls to participants to evaluate their satisfaction with the rendered services and to identify opportunities to improve the effectiveness of energy efficiency programs.

As shown in Table B-20, quality control activities occur during both pre-implementation and post-implementation phases of a program.

Table B-20: Quality Control Activities during Pre-Implementation and Post-Implementation Phases of a Program

Quality Control during Pre-Implementation
▪ **Documentation review:** Program documentation should be examined to ensure that it is complete and that it provides all essential information for achieving and verifying savings.
▪ **Site pre-inspection and interviews:** Site inspections may be conducted to verify preexisting conditions, quantities of measures, key operating parameters, equipment performance, and baseline assumptions in the measure documentation.
▪ **Measured data collection:** Addresses uncertainties regarding performance of measures or to confirm validity of assumptions used in the baseline analysis. May include spot measurements, data trending (via data loggers or building control systems), or other data collection conducted before measures are implemented.
Quality Control during Post-Implementation
▪ **Documentation retention:** Program-required documentation should be reviewed to ensure completeness and accuracy. All energy savings-related documentation should be retained for future savings validation or evaluation efforts.
▪ **Site post-inspection and interviews:** Site inspections and interviews may be conducted to verify that measures were installed and commissioned and operate as intended.
▪ **Measured data collection:** Data may be collected post-implementation to verify key operating parameters of measures or to meet requirements of an M&V plan.

Evaluation of programs by a TPE can also contribute to quality control of a program. In particular, quality control can be facilitated by having implementation and EM&V contractors coordinate and integrate their activities. Examples of how M&V activities can be coordinated and integrated with implementation activities include the following.

- *Pre-installation review*: This involves implementation and M&V contractor teams performing pre-installation review of measures and projects prior to a utility reserving incentive funding.
- *Project-Specific M&V Plans*: This involves implementation and M&V contractor teams coordinating to provide project-specific M&V plans for select projects to ensure the

implementation contractor has a full understanding of the M&V approach for these projects prior to the projects being completed and incentivized.

- *Coordinated joint site visits*: This involves implementation and M&V contractor teams coordinating to conduct joint site visits for select projects. Joint visits reduce the impact on customers and allow data to be collected concurrently, reducing conflicting information collected during separate site visits.
- *Project-Specific M&V Reports*: This involves sharing project-specific M&V reports with implementation contractors prior to final program level analysis.

Sharing analysis files, energy models, engineering spreadsheets, etc. maintains transparency and allows all calculations used in determining evaluated verified energy savings to be reviewed by all parties.

The TPE should also conduct quality control for the evaluation work. Examples of areas where quality control should be exercised for evaluation work include the following.

- Quality control assessment of evaluation plans with respect to the following
  - Analytical methods used to estimate savings
  - Baseline determination
  - Researchable questions
  - Sampling approaches and segmentation or stratification (if appropriate)
  - Data collection instruments and topics
  - Mapping inputs and outputs for computation of effects
  - Logical narrative
- Quality control assessment of data procurement:
  - Review of options for real time data collection
  - Use of appropriate data collection procedures for sampling, collection, processing, attrition, bias, etc.
  - How to best use data tracking systems to serve needs of both program implementation and evaluation
- Quality control of evaluation reporting
  - Consistency of reporting with the corresponding plan and with best practices
  - Cogency and clarity of reporting documentation
  - Critical assessment of conclusions and recommendations
  - Thoroughness of documentation of methods and results in reports

B.8. Protocol and Guidance for Updating the TRM

This protocol addresses the updating of the Technical Reference Manual (TRM). The protocol provides for periodically reviewing and, if appropriate, updating the content of the TRM. For many measures, updating may need to occur only when codes and standards affecting the specific measure change. Areas to focus on for major updating include:

- *Making changes to existing measures, data, and calculations* when significant changes are justified, typically because of changing baselines or availability of more current, applicable evaluation studies for updating values.
- *Including new measures* that are determined to be priorities in the TRM

The focus of the updating should be on areas of high impact in the Energy Smart portfolio (e.g., duct sealing) and of potential future high impact measures (e.g., ductless mini-split HVAC systems).

A study of an existing or new measure is warranted when the following guidelines are met.

- Measures should be flagged for further review if they exceed 1% of portfolio savings. In such instances, it should be determined whether:
  - Primary data have been collected in Energy Smart evaluations to support the deemed savings.
  - The data is sufficiently recent to support its continued use.
  - If data collection to support a deemed savings revision is cost-effective or cost-feasible, given the implementation and EM&V budgets for Energy Smart programs.
- Measures that are not over the high-impact threshold should be considered for impact or market assessment studies if:
  - Stakeholders (the Council and their Advisors, ENO, implementers, interveners, the EM&V contractor, and/or other appropriate parties) conclude a measure is of strategic importance to future program implementation efforts; or
  - A measure is high-impact within an important market sub-segment (such as low-income multifamily or municipal government).

Future implementation of Energy Smart programs may include measures that are not in the current version on the TRM. The treatment of these measures in the implementation and evaluation process will differ situationally.

- Many measures in the commercial and industrial segment are custom measures for which deemed savings are inappropriate. These measures will be validated individually based on IPMVP protocols.
- Direct load control (DLC) or load management (LM) programs curtail peak loads through installation of control devices on specific systems (DLC) or through voluntary

self-curtailment (LM). These programs are not appropriate for inclusion in a TRM and should have their performance validated annually.

The TRM should be updated each year through a two-stage process.

- In the first quarter of each calendar year, a technical forum will be held in which stakeholders may suggest measure additions or updates. This will inform the scope of TRM additions and/or updates to be completed that calendar year.
- Based on this scope, the EM&V contractor will develop the updates, and submit these for comment in July. The results of these comments will be discussed in a second technical conference in August, with the TRM updates finalized in September.

Measures that may be appropriate for the TRM but that are not included in the then-current version should be brought forward in the first-quarter technical conference when possible. If a measure is brought forward by program implementers or other stakeholders, the EM&V contractor may work with the appropriate stakeholders in finalizing an ad hoc measure whitepaper for use until the measure can be formalized in a TRM update. It is at the discretion of the EM&V contractor to determine if primary data collection is warranted before allowing deemed savings for measures through this whitepaper process.

Updating of the TRM should be accomplished using data and tools that are the “best available” (i.e., accurate, relevant, and current). In particular, TRM updates should be based on EM&V studies that are conducted regularly.

The ongoing annual updating process will provide assessments of the reliability of deemed savings values, deemed calculations, and deemed variables and factors. Such assessments may not necessarily result in changes to the TRM. However, the reviews should assess whether the use of the “best (currently) available” data regarding baseline assumptions remains accurate or needs updating (e.g., because of changing code requirements or changes in market practices).

C.Residential Measures

C.1. Appliances

C.1.1. ENERGY STAR® Clothes Washers

C.1.1.1. Measure Description

This measure involves the installation of a residential ENERGY STAR® clothes washer > 2.5 ft^3 in a new construction or replacement-on-burnout application. This measure applies to all residential applications.

C.1.1.2. Baseline and Efficiency Standards[57]

The baseline standard for deriving savings from this measure is the current federal minimum efficiency levels.

The efficiency standard is the ENERGY STAR® requirements for clothes washers.

Efficiency performance for clothes washers are characterized by Integrated Modified Energy Factor (IMEF) and Integrated Water Factor (IWF). The units for IMEF are ft^3/kWh/cycle. Units with higher IMEF values are more efficient. The units for IWF are gallons/cycle/ft^3. Units with lower IWF values will use less water and are therefore more efficient.

Table C-1: ENERGY STAR® Clothes Washer – Baseline and Efficiency Levels

Clothes Washer Configuration	***ENERGY STAR® Efficiency Level Effective 3/7/2015***
Top Loading	MEF ≥ 2.06 WF ≤ 4.3
Front Loading	MEF ≥ 2.38 WF ≤ 3.7

[57] Current federal standards for clothes washers can be found on the DOE website at: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.

Current ENERGY STAR® criteria for clothes washers can be found on the ENERGY STAR® website at: http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers.

ENERGY STAR® Most Efficient criteria for clothes washers can be found at: http://www.energystar.gov/ia/partners/downloads/most_efficient/2015/Final_ENERGY_STAR_Most_Efficient_2015_Recognition_Criteria_Clothes_Washers.pdf.

C.1.1.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 14 years, according to the US DOE.[58]

C.1.1.4. Deemed Savings Values

For retrofit situations, baseline and efficiency case energy consumption is based on the configuration of the replaced unit and new unit (top loading or front loading). For new construction applications, a top loading clothes washer is assumed as the baseline and the efficient equipment is either top loading or front loading.

Table C-2: ENERGY STAR® Clothes Washer – Deemed Savings

Baseline Configuration	Efficient Configuration	Water Heater Fuel Type	Dryer Fuel Type	kW Savings	kWh Savings
Top Loading	Top Loading	Gas	Gas	0.005	23
		Gas	Electric	0.045	192
		Electric	Gas	0.027	114
		Electric	Electric	0.067	282
Top Loading	Front Loading	Gas	Gas	0.009	38
		Gas	Electric	0.047	198
		Electric	Gas	0.045	191
		Electric	Electric	0.083	351
Front Loading	Front Loading	Gas	Gas	0.002	6
		Gas	Electric	0.022	93
		Electric	Gas	0.008	32
		Electric	Electric	0.028	119

C.1.1.5. Calculation of Deemed Savings

Energy savings for this measure were derived using the ENERGY STAR® Clothes Washer Savings Calculator.[59] Unless otherwise specified, all savings assumptions are extracted from the ENERGY STAR® calculator. The baseline and ENERGY STAR® efficiency levels are set to those matching Table C-1. The ENERGY STAR® calculator determines savings based on whether an electric or gas water heater is used. Calculations are also conducted based on whether the dryer is electric or gas.

For applications using an electric water heater and an electric dryer, the savings are calculated as follows:

$$kWh_{savings} = \left(E_{conv,machine} + E_{conv,WH} + E_{conv,dryer}\right) - \left(E_{ES,machine} + E_{ES,WH} + E_{ES,dryer}\right)$$

[58] U.S. DOE "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers" Section 8.2.3 Product Lifetimes. April 2012. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.

[59] The ENERGY STAR® Clothes Washer Savings Calculator can be found on the ENERGY STAR® website on the right hand side of the page at:www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

Where:

$E_{conv,machine}$= Conventional machine energy (kWh)

$E_{conv,WH}$= Conventional water heating energy (kWh)

$E_{conv,dryer}$= Conventional dryer energy (kWh)

$E_{ES,machine}$= ENERGY STAR® machine energy (kWh)

$E_{ES,WH}$= ENERGY STAR® water heating energy (kWh)

$E_{ES,dryer}$=ENERGY STAR® dryer energy (kWh)

C.1.1.5.1. Energy Savings

Energy consumption for the above factors can be determined using the following algorithms.

$$E_{conv,machine} = \frac{MCF \times RUEC_{conv} \times LPY}{RLPY}$$

$$E_{conv,WH} = \frac{WHCF \times RUEC_{conv} \times LPY}{RLPY}$$

$$E_{conv,dryer} = \left(\frac{CAP \times LPY}{IMEF_{FS}} - \frac{RUEC_{conv} \times LPY}{RLPY}\right) \times DUF$$

$$E_{ES,machine} = \frac{MCF \times RUEC_{ES} \times LPY}{RLPY}$$

$$E_{ES,WH} = \frac{WHCF \times RUEC_{ES} \times LPY}{RLPY}$$

$$E_{ES,dryer} = \left(\frac{CAP \times LPY}{IMEF_{ES}} - \frac{RUEC_{ES} \times LPY}{RLPY}\right) \times DUF$$

Where:

MCF= Machine electricity consumption factor = 20%

$WHCF$= Water heating electricity consumption factor = 80%

$RUEC_{conv}$= Rated unit electricity consumption (kWh/year) = 381 (Top Loading); 169 (Front Loading)

$RUEC_{ES}$ = Rated unit electricity consumption (kWh/year) = 230 (Top Loading); 127 (Front Loading)

CAP= Clothes washer capacity = 3.5 (ft^3)

$IMEF_{FS}$= Federal Standard Integrated Modified Energy Factor (ft^3/kWh/cycle)

$IMEF_{ES}$= ENERGY STAR® Integrated Modified Energy Factor (ft^3/kWh/cycle)

LPY = Loads per year = 295

$RLPY$= Reference loads per year = 392

DUF= Dryer use factor = 91%

C.1.1.5.2. Demand Savings

Demand savings are calculated using the following equation:

$$kW_{savings} = \frac{kWh_{savings}}{AOH} \times CF$$

AOH = Annual operating hours = LPY × d = 295 hours

CF = Coincidence factor = 0.07[60]

C.1.1.6. Incremental Cost

The incremental cost is $190[61].

C.1.1.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents. Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

[60] Value from Clothes Washer Measure, Mid Atlantic TRM 2014. Metered data from Navigant Consulting "EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program." March 21, 2014, p. 36.

[61] ENERGY STAR Appliance Calculator: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwihkoHI8f3OAhVW5mMKHe72Du4QFggeMAA&url=https%3A%2F%2Fwww.energystar.gov%2Fsites%2Fdefault%2Ffiles%2Fasset%2Fdocument%2Fappliance_calculator.xlsx&usg=AFQjCNFAy5-mu5GR3BjLp4MR1LqrOHegCA&sig2=8l5MGUh1_bJy3lSl9wAWIA

C.1.2. ENERGY STAR® Dryers

C.1.2.1. Measure Description

This measure involves the installation of a residential ENERGY STAR® dryers in a new construction or replacement-on-burnout application. This measure applies to all residential applications.

C.1.2.2. Baseline and Efficiency Standards[62]

The baseline standard for deriving savings from this measure is the current federal minimum efficiency levels. The efficiency standard is the ENERGY STAR® requirements for dryers.

ENERGY STAR® Clothes Dryers are more efficient than standard ones and save energy. They have a higher CEF (Combined Energy Factor) and may incorporate a moisture sensor to reduce excessive drying of clothes and prolonged drying cycles. ENERGY STAR® Heat pump dryers or ventless dryers have higher CEF than conventional ENERGY STAR® dryers.

Table C-3: ENERGY STAR® Dryer – Baseline and Efficiency Levels[63]

	Vented Gas Dryer	***Ventless or Vented Electric, Standard ≥ 4.4 ft³***	***Ventless or Vented Electric, Compact (120V) < 4.4 ft³***	***Vented Electric, Compact (240V) < 4.4 ft³***	***Ventless Electric, Compact (240V) < 4.4 ft³***	***Heat Pump Clothes Dryer***
ENERGY STAR® Required CEF	3.48	3.93	3.80	3.45	2.68	7.60
Federal standard CEF	2.84	3.11	3.01	2.73	2.13	3.11
Average load (in lbs.)	8.45	8.45	3.0	3.0	3.0	8.45
Default loads per year	283	283	283	283	283	283
Default capacity (in ft³)	5.0	5.0	3.0	3.0	3.0	5.0

[62] Current federal standards for clothes dryers can be found on the DOE website at: https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/36.

Current ENERGY STAR® criteria for clothes dryers can be found on the ENERGY STAR® website at: https://www.energystar.gov/products/appliances/clothes_dryers.

ENERGY STAR® Most Efficient criteria for clothes washers can be found at: http://www.energystar.gov/ia/partners/downloads/most_efficient/2015/Final_ENERGY_STAR_Most_Efficient_2015_Recognition_Criteria_Clothes_Washers.pdf.

[63] The ENERGY STAR® Clothes Dryer Savings Calculator can be found on the ENERGY STAR® website on the right hand side of the page at: www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW

C.1.2.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 12 years, according to the US DOE.[64]

C.1.2.4. Deemed Savings Values

For retrofit situations, baseline and efficiency case energy consumption is based on the size of the replaced unit and new unit. For new construction applications.

Table C-4: ENERGY STAR® Clothes Dryer – Deemed Savings

Product Type	Energy Savings (kWh/yr.)	Demand Reduction (kW)
Vented Electric, Standard (4.4 ft³ or greater capacity)	152.42	.0226
Vented Electric, Compact (120V) (less than 4.4 ft³ capacity)	55.71	.0083
Vented Electric, Compact (240V) < 4.4 ft³	61.66	.0092
Ventless Electric, Compact (240V) < 4.4 ft³	77.71	.0115
Heat Pump Clothes Dryer	431.56	.0641

C.1.2.5. Calculation of Deemed Savings

C.1.2.5.1. Energy and Demand Savings

Energy savings for this measure were derived using the ENERGY STAR® Dryer Savings Calculator.[65] Unless otherwise specified, all savings assumptions are extracted from the ENERGY STAR® calculator.

The energy and demand savings are obtained through the following formulas:

$$\Delta kWh/yr = Cycles_{wash} \times \%_{dry/wash} \times Load_{avg} \times \left(\frac{1}{CEF_{base}} - \frac{1}{CEF_{ee}}\right)$$

$$\Delta kW_{peak} = \frac{\left(\frac{1}{CEF_{base}} - \frac{1}{CEF_{ee}}\right) \times Load_{avg}}{time_{cycle}} \times CF$$

Where:

[64] U.S. DOE “Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Dryer” Section 8.2.3 Product Lifetimes. April 2011. https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/36.

[65] The ENERGY STAR®Clothes Washer Savings Calculator can be found on the ENERGY STAR® website on the right hand side of the page at:www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

$Cycles_{wash}$ = Number of washing machine cycles per year = 283 cycles/year

$Load_{avg}$ = Weight of average dryer load, in pounds per load = Standard Dryer: 8.45 lbs/load and Compact Dryer: 3.0 lbs/load[66] [67]

$\%_{\mathrm{dry/wash}}$ = Percentage of homes with a dryer that use the dryer every time clothes are washed = 95%

CEF_{base} = Combined Energy Factor of baseline dryer (lbs/kWh) = See Table C-3[68]

CEF_{ee} = Combined Energy Factor of ENERGY STAR® dryer (lbs./kWh) = See Table C-3[69]

$time_{cycle}$ = Duration of average drying cycle in hours = 1 hour

CF - Coincidence Factor = 0.042[70]

C.1.2.6. Incremental Cost

The incremental cost of high efficiency clothes dryers is detailed in Table C-5.

[66] Test Loads for Compact and Standard Dryer in Appendix D2 to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Clothes Dryers. http://www.ecfr.gov/cgi-bin/text-idx?SID=9d051184ada3b0d0b5b553f624e0ab05&node=10:3.0.1.4.18.2.9.6.14&rgn=div9

[67] 2011-04 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment. Residential Clothes Dryers and Room Air Conditioners, Chapter 7. Clothes Dryer Frequency from Table 7.3.3 for Electric Standard. http://www.regulations.gov/contentStreamer?objectId=0900006480c8ee11&disposition=attachment&contentType=pdf

[68] Federal Standard for Clothes Dryers, Effective January 1, 2015. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/36

[69] ENERGY STAR® Specification for Clothes Dryers Version 1.0, Effective January 1, 2015. http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Final%20Draft%20Version%201.0%20Clothes%20Dryers%20Specification_0.pdf

[70] 6) Central Maine Power Company. “Residential End-Use Metering Project”. 1988. Using 8760 data for electric clothes dryers, calculating the CF according to the PJM peak definition.

Table C-5: ENERGY STAR® Clothes Dryer Incremental Costs

Product Type	Incremental Cost
Vented Electric, Standard: (4.4 ft^3 or greater capacity)	$40[71]
Vented Electric, Compact (120V): (less than 4.4 ft^3 capacity)	$40
Vented Electric, Compact: (240V) < 4.4 ft^3	$40
Ventless Electric, Compact: (240V) < 4.4 ft^3	$40

C.1.2.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

[71] ENERGY STAR Appliance Calculator: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwihkoHI8f3OAhVW5mMKHe72Du4QFggeMAA&url=https%3A%2F%2Fwww.energystar.gov%2Fsites%2Fdefault%2Ffiles%2Fasset%2Fdocument%2Fappliance_calculator.xlsx&usg=AFQjCNFAy5-mu5GR3BjLp4MR1LqrOHegCA&sig2=8l5MGUh1_bJy3lSl9wAWIA

C.1.3. ENERGY STAR® Dishwashers

C.1.3.1. Measure Description

This measure involves the installation of an ENERGY STAR® dishwasher in a new construction or replacement-on-burnout situation. This measure applies to all residential applications.

C.1.3.2. Baseline and Efficiency Standards

The baseline for this measure is the current federal standard as displayed in the table below.

Table C-6: ENERGY STAR® Criteria for Dishwashers[72]

	ENERGY STAR® Criteria		
	Capacity	***Annual Energy Consumption (AEC) kWh/Year***	***Gallons/Cycle***
Standard Model Size (Effective Until 1/26/2016)	> 8 place settings + 6 serving pieces	< 295	< 4.25
Standard Model Size (Effective On 1/26/2016)[73]	> 8 place settings + 6 serving pieces	AECbase + AECadderconnected AECbase: 270 AECadderconnected: 0.05 × AECbase	< 3.5
Compact Model Size (Effective On 1/26/2016)	< 8 place settings + 6 serving pieces	< 203	< 3.1

C.1.3.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 15 years, according to the US DOE.[74]

C.1.3.4. Deemed Savings Values

Deemed savings are per installed unit based on the water heating fuel type.

[72] ENERGY STAR® criteria for dishwashers can be found on the ENERGY STAR® website at: www.energystar.gov/index.cfm?c=dishwash.pr_crit_dishwashers.

[73] ENERGY STAR® efficiency requirements as of January 26, 2016 are defined on their website at www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements_0.pdf.

[74] U.S. DOE, Technical Support Document: "Energy Efficiency Program for Consumer Products and Commercial Industrial Equipment: Residential Dishwashers, Section 8.2.3 Product Lifetimes." May 2012. http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0060-0007.

Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0060-0007.

Table C-7: ENERGY STAR® Dishwashers – Deemed Savings Values

	Water Heater Fuel Type	***kW Savings***	***kWh Savings***	***Therms Savings***
Standard Model Size	Gas	0.0005	5	0.3
Standard Model Size	Electric	0.0011	12	0.0

C.1.3.5. Calculation of Deemed Savings

C.1.3.5.1. Energy Savings

Energy savings for this measure were derived using the ENERGY STAR® Dishwasher Savings Calculator.[75] The baseline and ENERGY STAR® efficiency levels are set to those matching Table C-6 and Table C-7.

$$kWh_{Savings} = \left(E_{conv,machine} + E_{conv,WH}\right) - \left(E_{ES,machine} + E_{ES,WH}\right)$$

Where:

$E_{conv,machine}$= Conventional machine energy (kWh)

$E_{conv,WH}$= Conventional water heating energy (kWh)

$E_{ES,machine}$= ENERGY STAR® machine energy (kWh)

$E_{ES,WH}$= ENERGY STAR® water heating energy (kWh)

Algorithms to calculate the above parameters are defined as:

$$E_{conv,machine} = MCF \times RUEC_{conv}$$

$$E_{conv,WH} = WHCF \times RUEC_{conv}$$

$$E_{ES,machine} = MCF \times RUEC_{ES}$$

$$E_{ES,WH} = WHCF \times RUEC_{ES}$$

C.1.3.5.2. Demand Savings

Demand savings can be derived using the following:

$$kW_{Savings} = \frac{kWh_{Savings}}{AOH} \times CF$$

Where:

MCF= Machine electricity consumption factor = 44%

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[75] The ENERGY STAR® Dishwasher Savings Calculator, updated January 20, 2012, can be found on the ENERGY STAR® website.

$WHCF$= Water heating electricity consumption factor = 56%

$RUEC_{conv}$= Rated unit electricity consumption = 307 (kWh/year)

$RUEC_{ES}$ = Rated unit electricity consumption = 295 (kWh/year)

CPY = Cycles per year = 215

d = Average wash cycle duration = 2.1 hours[76]

AOH = Annual operating hours = CPY × d = 451.5 hours

CF = Coincidence factor = 0.036[77]

$\eta_{gas\ WH}$= Gas water heater efficiency = 75%

C.1.3.6. Incremental cost

The incremental cost of ENERGY STAR© Dishwashers is $10[78].

C.1.3.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

[76] Average of Consumer Reports Cycle Times for Dishwashers. http://www.consumerreports.org/cro/dishwashers.htm. Information available for subscribers only.

[77] Hendron, R. & Engebrecht, C. 2010, , National Renewable Energy Laboratory (NREL). "Building America Research Benchmark Definition: Updated December" US U.S. DOE. January 2010. p. 14 (peak hour of 4 PM was applied). http://www.nrel.gov/docs/fy10osti/47246.pdf

[78] ENERGY STAR Appliance Calculator: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwihkoHI8f3OAhVW5mMKHe72Du4QFggeMAA&url=https%3A%2F%2Fwww.energystar.gov%2Fsites%2Fdefault%2Ffiles%2Fasset%2Fdocument%2Fappliance_calculator.xlsx&usg=AFQjCNFAy5-mu5GR3BjLp4MR1LqrOHegCA&sig2=8l5MGUh1_bJy3lSl9wAWIA

C.1.4. ENERGY STAR® Water Coolers

C.1.4.1. Measure Description

This measure entails the replacement of an inefficient water cooler unit with an ENERGY STAR-rated, energy-efficient unit.

The categories of coolers considered are: Cook & Cold / Cold Only[79] units; and Hot and Cold units. Within these categories are three configurations: Top-loading; Bottom-loading; or Point-of-Use (POU). Top-loading and Bottom-loading are units in which a 3-gallon or a 5-gallon bottle can easily be installed. POU water coolers are bottle-less units that are installed directly to a water line. This chapter provides deemed savings for top and bottom-loading units; POU models are not eligible at this time.

C.1.4.2. Baseline and Efficiency Standards

The previous energy consumption baseline and the current energy-efficient energy consumption baseline for the two types of water coolers is shown in Table C-8.

Table C-8: Energy Consumption Baseline and ENERGY STAR Efficiency Criteria

Criteria	***Water Cooler Category***	***kWh Per Day***[80]
Standard	Cook & Cold	≤ 0.29 kWh/day
	Cold Only	
	Hot and Cold	≤ 2.19 kWh/day
ENERGY STAR	Cook & Cold	≤ 0.16 kWh/day
	Cold Only	
	Hot and Cold	≤ 0.87 kWh/day

C.1.4.3. Estimated Useful Life (EUL)

According to ENERGY STAR, the average lifetime for an energy-efficient water cooler unit is 10 years.[81]

C.1.4.4. Deemed Energy Savings and Demand Reductions

Calculated deemed energy savings are shown in Table C-9.

[79] Cook & Cold includes room temperature and refrigerated water, while Cold Only has one spout and only provides refrigerated water.

[80] The energy consumption baselines are deemed and are based on ENERGY STAR® Test Method for Water Coolers (Rev. May-2013).

[81] ENERGY STAR Water Cooler Savings Calculator. The current energy consumption baselines are deemed and apply to units that are tested using the "ON Mode with No Water Draw" Test)

Table C-9: Deemed kWh Savings and kW Reductions for Water Cooler Replacement

Water Cooler Category	**Annual kWh Savings**	**Peak kW Savings**
Cook & Cold	47.45 kWh	0.0053 kW
Cold Only		
Hot and Cold	481.8 kWh	0.054 kW

C.1.4.5. Calculation of Deemed Savings – Water Coolers

C.1.4.5.1. Energy Savings

Energy savings are based on the reduction of energy consumption resulting from replacing an inefficient water cooler unit with an energy-efficient unit and are calculated as follows:

$$kWh_{Savings} = \left(kWh_{base} - kWh_{efficient}\right) \times 365$$

Where:

kWh_{base} = Baseline daily kWh consumption of energy-inefficient unit (Table C-8)

$kWh_{efficient}$ = Daily kWh consumption of energy-efficient ENERGY STAR® model (Table C-8)

365 = The number of days in a year water cooler is operating

For example, if an inefficient Cold Only water cooler were to be replaced with a Cold Only ENERGY STAR® labeled efficient unit having an energy consumption rate of 0.16 kWh/day, then the annual energy savings would be:

$$kWh_{Savings} = (0.29 - 0.16) \times 365 = 47.45\ kWh$$

C.1.4.5.2. Demand Savings

$$kW_{savings} = kWh_{savings} \times Energy\ to\ Demand\ Factor\ (ETDF)$$

Where:

$ETDF = 0.0001119 \frac{kW}{kWh/year}$ [82]

Continuing the example calculation shown in the previous subsection, the peak demand reduction is:

$$kW_{savings} = 47.45\ {kWh}/{year} \times 0.0001119 \frac{kW}{kWh/year} = 0.0053\ kW$$

[82] Quantec in collaboration with Summit Blue Consulting, Nexant, Inc., A-TEC Energy Corporation, and Britt/Makela Group, prepared for the Iowa utility Association, February 2008. http://plainsjustice.org/files/EEP-08-1/Quantec/QuantecReportVol1.pdf

C.1.4.6. Incremental Cost

The TPE conducted a market study of currently available ENERGY STAR and non-ENERGY STAR water coolers to determine incremental pricing. Prices were collected from New Orleans retail websites. The range of models in the "Cook & Cold" category was very limited (particularly for ENERGY STAR-qualifying models).

Table C-10: Water Cooler Cost Summary

Type	Efficiency Level	Average Cost
Hot & Cold	Standard	$182.36 (n=22)
	Energy Star	$188.81 (n=28)
Cook & Cold	Standard	$123.18 (n=6)
	Energy Star	$127.52 (n=2)

The incremental cost of an ENERGY STAR Cook & Cold or a Cold Only unit is $4.34.

The incremental cost of an ENERGY STAR Hot and Cold unit is $6.45.

Due to low measure incremental costs, the TPE recommends incentivizing the measure through mid-stream channels.

C.1.4.1. Future Research

At the time of authorship of this chapter, this measure was not implemented in the Energy Smart program. Future EM&V should be conducted to update this measure to align with any new federal standards, as well as to establish a net-to-gross ratio. If program administrators obtain additional cost data for Cook & Cold systems, this should be provided so that the incremental cost for this measure category can be updated with a more robust sample size.

C.1.5. ENEGRY STAR® Air Purifiers

C.1.5.1. Measure Description

This measure involves the installation of an ENERGY STAR® certified room air purifier. An air purifier, also known as an air cleaner, is defined as a portable electric appliance that removes dust and fine particles from indoor air.

C.1.5.2. Baseline and Efficiency Standards

The baseline equipment is assumed to be a conventional unit[83].

The efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR®[84] as provided below:

- Must produce a minimum 50 Clean Air Delivery Rate (CADR) for Dust[85].
- Minimum Performance Requirement: = 2.0 CADR/Watt (Dust)
- Standby Power Requirement: = Measured standby power shall not exceed 2 Watts.
- UL Safety Requirement: Models that emit ozone as a byproduct of air cleaning must meet UL Standard 867 (ozone production must not exceed 50ppb).

C.1.5.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 9 years, according to ENERGY STAR®.

C.1.5.4. Deemed Savings

Table C-11 summarizes the deemed kWh and kW based on clean air delivery rate.

Table C-11. ENERGY STAR® Air Purifiers Deemed Savings

Clean Air Delivery Rate (CADR)	CADR used in calculation (midpoint)	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR Unit Energy Consumption (kWh/year)	kWh Savings	kW Savings
CADR 50-100	75	441	148	293	0.065
CADR 101-150	125	733	245	488	0.108
CADR 151-200	175	1025	342	683	0.152
CADR 201-250	225	1317	440	877	0.195
CADR Over 250	300	1755	586	1169	0.260

C.1.5.5. Incremental Cost

The incremental cost for this measure is $0[86].

[83] As defined as the average of non-ENERGY STAR products found in EPA research, 2011, ENERGY STAR Qualified Room Air Cleaner Calculator.

[84] ENERGY STAR® Air Cleaner Specification v1.2, July 10, 2011, https://www.energystar.gov/products/appliances/air_purifiers_cleaners/key_product_criteria

[85] Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard

[86] ENERGY STAR® Appliances Calculator.

C.1.6. ENERGY STAR® Ceiling Fans

C.1.6.1. Measure Description

ENERGY STAR® ceiling fans require a more efficient CFM/Watt rating at the low, medium, and high settings than standard ceiling fans as well ENERGY STAR® qualified lighting for those with light kits included. Both of these features save energy compared to standard ceiling fans.

C.1.6.2. Estimated Useful Life (EUL)

The measure life for ceiling fans is 20 years.[87]

C.1.6.3. Deemed Savings

Deemed savings are calculated for fan-only ceiling fans.

Table C-12: ENERGY STAR® Ceiling Fan – Deemed Savings

Fan Type	Energy Savings (kWh)	Demand Reduction (kW)
ENERGY STAR® Lighting	68.9	.0087
Fan Only	16.0	0.00132

C.1.6.4. Calculation of Deemed Savings

C.1.6.4.1. Energy Savings - Fan

The energy savings are obtained through the following formula:

$$\Delta kWh = \left[\left(\%_{low} \times (Low_{base} - Low_{ee})\right) + \left(\%_{med} \times (Med_{base} - Med_{ee})\right) + \left(\%_{high} \times (High_{base} - High_{ee})\right)\right] \times \frac{1\ kW}{1000\ W} \times HOU_{fan} \times 365\frac{days}{yr}$$

Where:

$\%_{low}$ = percentage of low setting use = 40%[88]

$\%_{med}$ = percentage of medium setting use = 40%[88]

$\%_{high}$ = percentage of high setting use = 20%[88]

Low_{base} = Wattage of low setting, baseline (W) = 15W[88]

Med_{base} = Wattage of medium setting, baseline (W) = 34W[88]

$High_{base}$ = Wattage of high setting, baseline (W) = 67W[88]

[87] Residential and C&I Lighting and HVAC Report Prepared for SPWG, 2007. Pg. C-2.

[88] ENERGY STAR® Lighting Fixture and Ceiling Fan Calculator. Updated September, 2013

Low_{ee} = Wattage of low setting, ENERGY STAR® (W) = 4.8W[89,90]

Med_{ee} = Wattage of medium setting, ENERGY STAR® (W) = 18.2W[89,90]

$High_{ee}$ = Wattage of high setting, ENERGY STAR® (W) = 45.9W[89,90]

HOU_{fan} = fan daily hours of use (hours/day) = 3 hours/day[88]

C.1.6.4.2. Energy Savings – Lighting

The energy savings from lighting apply the deemed savings assumptions specified in the Residential Lighting chapter of this TRM. The assumed configuration is (3) 14W CFLs, applying a 43W baseline. Other inputs may be applied by program implementers if model-specific information is available.

C.1.6.4.3. Demand Savings – Lighting

Demand savings are calculated in accordance with protocols specified in the Residential Lighting chapter.

C.1.6.4.4. Demand Savings - Fans

Demand savings result from the lower connected load of the ENERGY STAR® fan and ENERGY STAR® lighting. Peak demand savings are estimated using a Coincidence Factor (CF).

$$\Delta kW = \left[\left(\%_{low} \times (Low_{base} - Low_{ee})\right) + \left(\%_{med} \times (Med_{base} - Med_{ee})\right) + \left(\%_{high} \times (High_{base} - High_{ee})\right)\right] \times \frac{1\ kW}{1000\ W} \times CF$$

Where:

CF = Demand Factor= 0.091[91]

C.1.6.5. Incremental Cost

The incremental cost of a three-lamp ENERGY STAR Ceiling Fan is \$46[92].

C.1.6.6. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using

89 ENERGY STAR® Ceiling Requirements Version 3.0

90 ENERGY STAR® Certified Ceiling Fan List, Accessed April 3, 2014.

91 EmPOWER Maryland 2012 Final Evaluation Report: Residential Lighting Program, Prepared by Navigant Consulting and the Cadmus Group, Inc., March 2013, Table 50.

92 ENERGY STAR® Lighting Fixture and Ceiling Fan Calculator. Updated September, 2013

ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of the models actually incented through the program. The key parameters to be examined include:

- Content of the lighting included with the fan;
- Rated wattage of the fans at low, medium, and high speeds.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

C.1.7. Advanced Power Strips

C.1.7.1. Measure Description

This measure involves the installation of a multi-plug Advanced Power Strip (APS, also known as "Smart Strips") that has the ability to automatically disconnect specific loads depending on the power draw of a specified or "master" load.

There are two categories of smart strips:

1) **Tier 1:** Tier 1 advanced power strips have a master controls socket arrangement and will shut off items plugged into the controlled power-saver sockets when the sense that the appliance plugged into the master socket has been turned off. The power-saving functions of the control sockets is not used when the master appliance is turned on.
2) **Tier 2:** Tier 2 advanced power strips manage both active and standby consumption. Tier 2 smart strips manage standby power consumption by turning off devices from a control event; this could be a TV or other item powering off, which then powers off the controlled outlets to save energy. Active power consumption is managed by monitoring a user's engagement or presence in a room either by infrared remote signals or motion sensing. After a period of inactivity, the Tier 2 unit will shut off controlled outlets.

C.1.7.2. Expected Useful Life

For Tier 1 advanced power strips, the EUL is 10 years[93].

For Tier 2 advanced power strips, there has not been a study performed to validate EUL. Until better data is available, they should default to using the current EUL of Tier 1 devices.

C.1.7.3. Baseline & Efficiency Standard

The baseline case is the absence of an APS, where peripherals are plugged in to a traditional surge protector or wall outlet.

The efficiency standard case is the presence of an APS, with all peripherals plugged into the APS.

[93] New York State Energy Research and Development Authority (NYSERDA) 2011, *Advanced Power Strip Research Report*, p. 30. August.

C.1.7.1. Deemed Savings Values

Table C-13: Deemed Savings for Residential APS

Tier	Size	Usage	kW Savings	kWh Savings
1	5-plug	Unspecified	.0056	48.9
		Entertainment	.0077	62.1
		Computer	.0037	35.8
	7-plug	Unspecified	.0067	57.7
		Entertainment	.0092	74.5
		Computer	.0045	42.9
2	5-plug	Unspecified	.0194	204.2
		Entertainment	.0316	307.4
		Computer	.0172	100.9

C.1.7.2. Estimated Useful Life (EUL)

The measure life is 10 years according to the NYSERDA Advanced Power Strip Research Report from August 2011.[94]

C.1.7.3. Calculation of Deemed Savings

Energy and demand savings for a 5-plug APS in use in a home office or for a home entertainment system are calculated using the following algorithm, where kWh saved are calculated and summed for all peripheral devices:

Tier 1:

$$\Delta kWh/yr._{\text{unspecified use}} = \frac{(kW_{\text{comp idle}} \times HOU_{\text{comp idle}}) + (kW_{\text{TVidle}} \times HOU_{\text{TV idle}})}{2} \times 365 \frac{\boldsymbol{days}}{\boldsymbol{yr}} \times ISR = 48.9\ kWh\ (5\text{-plug});\ 57.7\ kWh\ (7\text{-plug})$$

$$\Delta kWh/yr._{\text{entertainment center}} = kW_{TV\ idle} \times HOU_{TV\ idle} \times 365 \frac{days}{yr} \times ISR = 62.1\ kWh\ (5\text{-plug});\ 74.5\ kWh\ (7\text{-plug})$$

$$\Delta kWh/yr._{\text{computer}} = kW_{Comp\ idle} \times HOU_{Comp\ idle} \times 365 \frac{days}{yr} \times ISR = 35.8\ kWh\ (5\text{-plug});\ 42.9\ (7\text{-plug})$$

$$\Delta kW_{peak}\ \text{unspecified use} = \frac{CF \times (kW_{comp\ idle} + kW_{TV\ idle})}{2} \times ISR = 0.0056\ kW\ (5\text{-plug});\ 0.0067\ kW\ (7\text{-plug})$$

$$\Delta kW_{peak}\ \text{entertainment center} = CF \times kW_{TV\ idle} \times ISR = 0.0077\ kW\ (5\text{-plug});\ 0.0092\ kW\ (7\text{-plug})$$

$$\Delta kW_{peak}\ \text{Computer} = CF \times kW_{Comp\ idle} \times ISR = 0.0037\ kW\ (5\text{-plug});\ 0.0045\ kW\ (7\text{-plug})$$

Tier 2 Smart Strip:

[94] New York State Energy Research and Development Authority (NYSERDA) 2011, *Advanced Power Strip Research Report*, p. 30. August.

$$\Delta kWh\ unspecified\ use = \frac{(kWh_{comp} + kWh_{TV})}{2} \times ESF \times ISR = 204.2\ kWh$$

$$\Delta kWh\ entertainment\ center = kWh_{TV} \times ESF \times ISR = 307.4\ kWh$$

$$\Delta kWh\ Computer = kWh_{Comp} \times ESF \times ISR = 100.9\ kWh$$

$$\Delta kW_{peak}\ unspecified\ use = \frac{CF \times (\Delta kWh_{comp} + \Delta kWh_{entertainment})}{2 \times 8760 \frac{hours}{yr}} \times ISR = 0.0194\ kW$$

$$\Delta kW_{peak}\ entertainment\ center = \frac{CF \times \Delta kWh_{entertainment}}{8760 \frac{hours}{yr}} \times ISR = 0.0316\ kW$$

$$\Delta kW_{peak}\ Computer = \frac{CF \times \Delta kWh_{computer}}{8760 \frac{hours}{yr}} \times ISR = 0.0172\ kW$$

Table C-14: APS Assumptions

Parameter	***Unit***	***Value***	***Source***
kWcomp idle, Idle kW of computer system	kW	.0049 (5-plug) .00588 (7-plug)	95, 96, 97
HOUcomp idle, Daily hours of computer idle time	Hours/day	20	95
kWTV idle, Idle kW of TV system	kW	. 0085 (5-plug) .00102 (7-plug)	95, 97
HOUTV idle, Daily hours of TV idle time	Hours/day	20	95
kWhTV, Annual kWh of TV system	kWh	602.8	97
kWhcomp, Annual kWh of computer system	kWh	197.9	97
ISR, In-Service-Rate	%	1.0	
CF, Coincidence Factor	%	Entertainment Center = .90 Computer System= .763 Unspecified = .832	98
ESF, Energy Savings Factor. Percent of baseline energy consumption saved by installing the measure	%	Entertainment Center = .51	99

[95] "Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes", Energy Center of Wisconsin, May 2010.

[96] "Smart Plug Strips", ECOS, July 2009.

[97] "Advanced Power Strip Research Report", NYSERDA, August 2011"

[98]C F Values of Standby Losses for Entertainment Center and Home Office in Efficiency Vermont TRM, 2013, pg. 16. Developed through negotiations between Efficiency Vermont and the Vermont Department of Public Service

[99] "Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive," California Plug Load Research Center, 2014. http://www.efi.org/docs/studies/calplug_tier2.pdf

C.1.7.4. Incremental Cost

The incremental cost for APS systems is as follows:

Tier (1) – 5-plug: $16[100]

Tier (1) – 7-plug: $26[101]

Tier (2): $65[102]

C.1.7.1. Net-to-Gross Ratio

The NTGR for this measure is 80%[103] for direct install applications.

C.1.7.2. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure had exceedingly low participation in Energy Smart programs (a total of 336 kWh in PY6). As a result, savings are calculated using values cited from evaluation reports completed on behalf of the New York State Energy Research & Development Authority (NYSERDA) and Wisconsin Focus on Energy. If participation reached 1% of residential Energy Smart program savings, the evaluation should include fieldwork to support in-service rates and to document an inventory of the equipment actually installed into the APS by New Orleans residents.

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[100] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4

[101] Ibid

[102] California Technology Forum, June 2015: https://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556e25a3e4b06957271187a1/1433281955286/2015-01-15+Tier+2+Advance+Power+Strip+Cal+TF+Workpaper+Presentation_January.pdf

[103] Based on primary data collection from 37 PY6-9 program participants.

C.1.8. ENERGY STAR® Dehumidifiers

C.1.8.1. Measure Description

This measure is portable and whole-house humidifiers which meet the minimum qualifying efficiency standard set forth by the current ENERGY STAR® Version 5.0 (effective 10/31/2019[104]) and ENERGY STAR® Most Efficient 2019 Criteria (effective 01/01/2019) that are purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

C.1.8.2. Baseline and Efficiency Standards

C.1.8.2.1. Definition of Efficient Equipment

To qualify for this measure, the new dehumidifier must meet the ENERGY STAR ® standards as defined in Table C-15.

Table C-15: ENERGY STAR® Dehumidifier Standard

Equipment Specification	***Capacity (pints/day)***	***Federal Standard Criteria (L/kWh)***
Portable Dehumidifier	Up to 25	≥ 1.57
	≤ 25.01 to ≤ 50	≥ 1.80
	≥ 50.01	≥ 3.30
Equipment Specification	***Product Case Volume (cubic feet)***	***Federal Standard Criteria (L/kWh)***
Whole-home Dehumidifier	Up to 8	≥ 2.09
	≥ 8.01	≥ 3.30

Qualifying units shall be equipped with an adjustable humidistat control or shall require a remote humidistat control to operate.

C.1.8.2.2. Definition of Baseline Equipment

The baseline condition for this measure is a new dehumidifier that meets the federal efficiency standards. The Federal Standard for Dehumidifiers as of June 13, 2019 are defined in Table C-16 below.

Table C-16: Federal Minimum Standards for Dehumidifiers[105]

Equipment Specification	***Capacity (pints/day)***	***Federal Standard Criteria (L/kWh)***
Portable Dehumidifier	Up to 25	≥ 1.30
	≤ 25.01 to ≤ 50	≥ 1.60
	≥ 50.01	≥ 2.80
Equipment Specification	***Product Case Volume (cubic feet)***	***Federal Standard Criteria (L/kWh)***
Whole-home Dehumidifier	Up to 8	≥ 1.77
	≥ 8.01	≥ 2.41

C.1.8.3. Estimated Useful Life (EUL)

The assumed lifetime of a portable dehumidifier is 11 years while a whole house dehumidifier is 19 years.[106]

C.1.8.4. Energy and Demand Savings

Energy savings and demand reductions for residential dehumidifiers are based on the energy consumption. The following subsections outline deemed calculations for energy savings and demand reductions, respectively.

C.1.8.4.1. Annual Energy Savings

$$\Delta kWh = \left[\frac{(Avg\ Cap * 0.473)}{24} \times Hours\right] \times \left[\left(\frac{1}{L/kWh_{Base}}\right) - \left(\frac{1}{L/kWh_{Eff}}\right)\right]$$

Where:

Avg Cap = Average capacity of the unit (pints/day)

= Actual, if unknown assume capacity in each capacity range as provided in table below, or if capacity range unknown assume average.

0.473 = Constant to convert Pints to Liters

24 = Constant to convert Liters/day to Liters/hour

[105] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20Version%205.0%20Program%20Requirements.pdf

[106] https://www.federalregister.gov/documents/2016/06/13/2016-12881/energy-conservation-program-energy-conservation-standards-for-dehumidifiers#h-71

Hours	= Run hours per year
	= 1632[107]
L/kWh	= Liters of water per kWh consumed, as provided in tables above

Estimated annual kWh use for each capacity class are presented below in Table C-17.

Table C-17: Annual Energy Savings by Capacity Range

Portable Dehumidifiers					***Annual Use***		
Capacity Range	***Capacity Used***	***Federal Standard***	***ENERGY STAR***	***ENERGY STAR Most Efficient***[108]	***Federal Standard***	***ENERGY STAR***	***ENERGY STAR Most Efficient***
(pints/day)	***(pints/day)***	***(≥L/kWh)***	***(≥L/kWh)***	***(≥L/kWh)***	***(kWh)***	***(kWh)***	***(kWh)***
Up to 25	25	1.3	1.57	2.2	619	512	366
≥ 25.01 to ≤ 50	41.1	1.6	1.8	2.2	827	735	691
≥ 50.01	76.6	2.8	3.3	N/A	880	747	N/A
Whole House					***Federal Standard***	***ENERGY STAR***	***ENERGY STAR Most Efficient***
(cubic feet)	***(pints/day)***[109]	***(≥L/kWh)***	***(≥L/kWh)***	***(≥L/kWh)***	***(kWh)***	***(kWh)***	***(kWh)***
Up to 8	Up to 59.2	1.77	2.09	2.3	1,076	911	828
> 8	> 59.2	2.41	3.3	N/A	790	577	N/A

Deemed annual kWh savings for each capacity class are presented below in Table C-18.

[107] ENERGY STAR Dehumidifier Calculator; 24-hour operation over 68 days of the year.

[108] ENERGY STAR 2019 Most Efficient Criteria exclude the following products from eligibility; dehumidifiers with capacity of 75 pints/day or higher, portable dehumidifiers with capacity of 50.01 pints/day or higher, and whole home dehumidifiers with case volume greater than 8.0 cubic feet.

[109] The capacity and relative weighting of the whole-home dehumidifiers was sourced from the average capacity of portable dehumidifiers as there were no whole-home dehumidifiers on the ENERGY STAR Qualified Products List, as accessed in May 2019. See "Dehumidifier Calcs_05062019.xls.

Table C-18: Annual Energy Savings by Capacity Range

System Type	Capacity Range	Capacity Used	ENERGY STAR Savings (kWh)	ENERGY STAR Most Efficient Savings(kWh)
Portable (Pints/Day)	Up to 25	25	106	253
	>25 to ≤ 50	41.1	92	225
	> 50	76.6	133	N/A
Whole House (Cubic Feet)	Up to 8	59.2	165	248
	> 8	59.2	213	N/A

C.1.8.4.2. Demand Savings

$$\Delta kW = (\Delta kWh/Hours) * CF$$

Where:

Hours = Annual operating hours

=1632 hours[110]

CF = Summer Peak Coincidence Factor for measure

= 0.37[111]

Demand results for each capacity range are presented below in Table C-19.

Table C-19: Demand Reductions by Capacity Range

System Type	Capacity Range	Peak kW Savings	
		ENERGY STAR	ENERGY STAR Most Efficient
Portable (Pints/Day)	Up to 25	0.024	0.057
	>25 to ≤50	0.021	0.051
	> 50	0.03	N/A
Whole House (Cubic Feet)	Up to 8	0.037	0.056
	> 8	0.048	N/A

110 Based on 68 days of 24 hour operation; ENERGY STAR Dehumidifier Calculator

111Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1632 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1632/4392 = 37.2%

C.1.8.5. Demand Measure Cost

The incremental cost for an ENERGY STAR® unit is assumed to be $10.29[112] and for an ENERGY STAR® Most Efficient unit is $75[113].

C.1.8.6. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents. If there is notable participation from this measure, primary research may be conducted to develop a New Orleans-specific estimate of days per year of operation to override the ENERGY STAR estimate of 68 days per year.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

[112] Based on incremental costs sourced from the 2016 ENERGY STAR Appliance Calculator and weighted by capacity based on ENERGY STAR qualified products, accessed on May 2019.

[113] DOE Energy Conservation Standards for Residential Dehumidifiers, Appliance and Equipment Standard, 10 CFR Part 430, July 23, 2012, page 73. The sourced table is an analysis on the incremental manufacturer product costs on dehumidifiers with varying incentive levels. Assuming the markup costs between the baseline units and the most efficient units are equal. The incremental cost reproduced is a straight average of all the dehumidifiers, both stand alone and whole house, with an efficiency level meeting or exceeding ENERGY STAR's Most Efficient criteria. Opted to combine the incremental cost into one value because the stand alone and whole house incremental costs were near identical.

C.1.9. ENERGY STAR® Pool Pumps

C.1.9.1. Measure Description

This measure involves the replacement of a single-speed pool pump with an ENERGY STAR® certified variable speed or multi-speed pool pump. This measure applies to all residential applications; however, pools that serve multiple tenants in a common area are not eligible for this measure.

Multi-speed pool pumps are an alternative to variable speed pumps. The multi-speed pump uses an induction motor that is basically two motors in one, with full-speed and half-speed options. Multi-speed pumps may enable significant energy savings. However, if the half-speed motor is unable to complete the required water circulation task, the larger motor will operate exclusively. Having only two speed-choices limits the ability of the pump motor to fine-tune the flow rates required for maximum energy savings.[114] Therefore, multi-speed pumps must have a minimum size of 1 horsepower (HP) to be eligible for this measure.

C.1.9.2. Baseline and Efficiency Standards

The baseline condition is a 0.5-3 horsepower (HP) standard efficiency single-speed pool pump.

The high efficiency condition is a 0.5-3 HP ENERGY STAR® certified variable speed or multi-speed pool pump.

C.1.9.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life for this measure is 10 years.[115]

C.1.9.4. Deemed Savings Values

Deemed savings are per installed unit based on the pump horsepower.

[114] Hunt, A. & Easley, S., 2012, "*Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings.*" Building America Retrofit Alliance (BARA), U.S. U.S. DOE. May/. http://www.nrel.gov/docs/fy12osti/54242.pdf.

[115] Database for Energy Efficient Resources (2014). http://www.deeresources.com/.

Table C-20: Variable Speed Pool Pumps – Deemed Savings Values

Pump HP	kW Savings	kWh Savings
0.5	0.24	1,713
0.75	0.28	1,860
1	0.36	2,063
1.5	0.47	2,465
2	0.52	2,718
2.5	0.57	2,838
3	0.72	3,364

Table C-21: Multi-Speed Pool Pumps – Deemed Savings Values

Pump HP	kW Savings	kWh Savings
1	0.30	1,629
1.5	0.40	1,945
2	0.41	1,994
2.5	0.46	2,086
3	0.54	2,292

C.1.9.5. Calculation of Deemed Savings

C.1.9.5.1. Energy Savings

Energy savings for this measure were derived using the ENERGY STAR® Pool Pump Savings Calculator.[116]

$$kWh_{Savings} = kWh_{conv} - kWh_{ES}$$

Where:

kWh_{conv}= Conventional single-speed pool pump energy (kWh)

kWh_{ES}= ENERGY STAR® variable speed pool pump energy (kWh)

Algorithms to calculate the above parameters are defined as:

$$kWh_{conv} = \frac{PFR_{conv} \times 60 \times hours_{conv} \times days}{EF_{conv} \times 1000}$$

$$hours_{conv} = \frac{V_{pool} \times PT}{PFR_{conv} \times 60}$$

$$kWh_{ES} = kWh_{HS} + kWh_{LS}$$

[116] The ENERGY STAR® Pool Pump Savings Calculator, updated February 2013, can be found on the ENERGY STAR® website at: https://www.energystar.gov/products/certified-products/detail/pool-pumps.

$$kWh_{HS} = \frac{PFR_{HS} \times 60 \times hours_{HS} \times days}{EF_{HS} \times 1000}$$

$$kWh_{LS} = \frac{PFR_{LS} \times 60 \times hours_{LS} \times days}{EF_{LS} \times 1000}$$

$$PFR_{LS} = \frac{V_{pool}}{t_{turnover} \times 60}$$

Where:

kWh_{HS} = ENERGY STAR® variable speed pool pump energy at high speed (kWh)

kWh_{LS} = ENERGY STAR® variable speed pool pump energy at low speed (kWh)

$hours_{conv}$ = Conventional single-speed pump daily operating hours (Table C-22)

$hours_{HS,VS}$ = ENERGY STAR® variable speed pump high speed daily operating hours = 2 hours

$hours_{LS,VS}$ = ENERGY STAR® variable speed pump low speed daily operating hours = 10 hours

$hours_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed daily operating hours = 2 hours

$hours_{LS,VS}$ = ENERGY STAR® multi-speed pump low speed daily operating hours (Table C-23)

$days$ = Operating days per year = 7 months x 30.4 days/month = 212.8 days (default)

PFR_{conv} = Conventional single-speed pump flow rate (gal/min) (Table C-22)

$PFR_{HS,VS}$ = ENERGY STAR® variable speed pump high speed flow rate = 50 gal/min (default)

$PFR_{LS,VS}$ = ENERGY STAR® variable speed pump low speed flow rate (gal/min) = 30.6 (default)

$PFR_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed flow rate (gal/min) (Table C-23)

$PFR_{LS,MS}$ = ENERGY STAR® multi-speed pump low speed flow rate (gal/min) (Table C-23)

EF_{conv} = Conventional single-speed pump energy factor (gal/W·hr) (Table C-22)

$EF_{HS,VS}$ = ENERGY STAR® variable speed pump high speed energy factor = 3.75 gal/W·hr (default)

$EF_{LS,VS}$ = ENERGY STAR® variable speed pump low speed energy factor = 7.26 gal/W·hr (default)

$EF_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed energy factor (gal/W·hr) (Table C-23)

$EF_{LS,MS}$ = ENERGY STAR® multi-speed pump low speed energy factor (gal/W·hr) (Table C-23)

V_{pool} = Pool volume = 22,000 gal (default)

PT = Pool turnovers per day = 1.5 (default)

$t_{turnover,VS}$ = Variable speed pump time to complete 1 turnover = 12 hours (default)

$t_{turnover,MS}$ = Multi-speed pump time to complete 1 turnover (Table C-23)

60 = Constant to convert between minutes and hours

1000 = Constant to convert W to kW

Table C-22: Conventional Pool Pumps Assumptions

Pump HP	$hours_{conv}$	PFR_{conv} (gal/min)	EF_{conv} (gal/W·h)
0.5	11.0	50.0	2.71
0.75	10.4	53.0	2.57
1	9.2	60.1	2.40
1.5	8.6	64.4	2.09
2	8.5	65.4	1.95
2.5	8.1	68.4	1.88
3	7.5	73.1	1.65

Table C-23: ENERGY STAR® Multi-Speed Pool Pumps Assumptions

Pump HP	$t_{,turnover,M}S$	$hours_{MS,LS}$	$PFR_{HS,MS}$ (gal/min)	$EF_{HS,MS}$ (gal/W·h)	$PFR_{LS,MS}$ (gal/min)	$EF_{LS,MS}$ (gal/W·h)
1	11.8	9.8	56.0	2.40	31.0	5.41
1.5	11.5	9.5	61.0	2.27	31.9	5.43
2	11.0	9.0	66.4	1.95	33.3	5.22
2.5	10.8	8.8	66.0	2.02	34.0	4.80
3	9.9	7.9	74.0	1.62	37.0	4.76

C.1.9.5.2. Demand Savings

Demand savings can be derived using the following:

$$kW_{Savings} = \left[\frac{kWh_{conv}}{hours_{conv}} - \left(\frac{kWh_{HS} + kWh_{LS}}{hours_{HS} + hours_{LS}}\right)\right] \times \frac{CF}{days}$$

Where:

CF = Coincidence factor[117] = 0.31

C.1.9.6. Incremental Cost

The incremental cost for ENERGY STAR Pool Pumps is[118]:

- $549 for Variable Speed
- $235 for Multi-Speed

C.1.9.7. Future Studies

This measure has low-to-moderate participation in Energy Smart programs. In PY6, pool pump savings totaled 19,157 kWh. If measure savings reach a minimum of 500,000 kWh in a program year, the TPE recommends a metering study to validate usage assumptions.

Deemed parameters should be updated whenever DOE standard s or other applicable codes warrant it.

[117] Southern California Edison (SCE) Design & Engineering Services, 2008., *"Pool Pump Demand Response Potential, DR 07.01 Report."* June 2008. Derived from Table 16 assuming a peak period of 2-6 PM.

[118] ENERGY STAR Pool Pump Calculator

C.1.10. ENERGY STAR® Refrigerators

C.1.10.1. Measure Description

This measure involves replace-on-burnout or early retirement of an existing refrigerator and installation of a new, full-size (7.75 ft^3 or greater) ENERGY STAR® refrigerator. This measure applies to all residential or small commercial applications.

To qualify for early retirement, the ENERGY STAR® unit must replace an existing, full-size, working unit that is at least six years old. For early retirement, the maximum lifetime age of an eligible piece of equipment is capped at the point at which it is expected that 75 percent of the equipment has failed. Where the age of the unit exceeds the 75 percent failure age, ROB savings should be applied. This cap prevents early retirement savings from being applied to projects where the age of the equipment greatly exceeds the estimated useful life of the measure.

C.1.10.2. Baseline and Efficiency Standards[119]

For ROB, the baseline for refrigerators is the DOE minimum efficiency standards for refrigerators, effective September 15, 2014.

For an individual refrigerator early retirement program, the baseline for refrigerators is assumed to be the annual unit energy consumption of the refrigerator being replaced, as reported by the Association of Home Appliance Manufacturers (AHAM) refrigerator database120, adjusted for age according to the formula in the Measure Savings Calculations section. AHAM energy use data includes the average manufacturer-reported annual kilowatt hour usage, by year of production. This data dates back to the 1970s.

Alternatively, the baseline annual kilowatt hour usage of the refrigerator being replaced may be estimated by metering for a period of at least three hours using the measurement protocol specified in the US DOE report, "*Incorporating Refrigerator Replacement into the Weatherization Assistance Program*."[121]

To determine annual kWh of the refrigerator being replaced, use the formula:

$$kWh/yr = \frac{WH \times 8{,}760}{h \times 1{,}000}$$

[119] Current federal standards for refrigerators can be found on the DOE website at: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43. Current ENERGY STAR® criteria for refrigerators can be found on the ENERGY STAR® website at: www.energystar.gov/index.cfm?c=refrig.pr_crit_refrigerators

[120] AHAM Refrigerator Database. http://rfdirectory.aham.org/AdvancedSearch.aspx

[121] Moore, A. 2001, D&R International, Ltd. *"Incorporating Refrigerator Replacement into the Weatherization Assistance Program: Information Tool Kit."* U.S. DOE. November 19. http://www.waptac.org/data/files/website_docs/training/standardized_curricula/curricula_resources/refrigerator_info_toolkit.pdf

Where:

WH = the watt-hours metered during a time period

h = measurement time period (hours)

$8{,}760$ = hours in a year

$1{,}000$ watt-hours = 1 kWh

For the early retirement application, all new refrigerators must replace refrigerators currently in use, and all replaced refrigerators must be dismantled in an environmentally-safe manner in accordance with applicable federal, state, and local regulations. The installer will provide documentation of proper disposal of refrigerators.

Newly-installed refrigerators must meet current ENERGY STAR® efficiency levels. All newly-installed refrigerators must be connected to an adequately-sized electrical receptacle and be grounded in accordance to the National Electric Code (NEC).

Minimum efficiency requirements for ENERGY STAR® refrigerators are set at 10% more efficient than required by the minimum federal government standard. The standard varies depending on the size and configuration of the refrigerator. See Table C-24.

Configuration Codes (Table C-24):

BF: Bottom Freezer

SD: Refrigerator Only – Single Door

SR: Refrigerator/Freezer – Single Door

SS: Side-by-Side

TF: Top Freezer

TTD: Through the Door (Ice Maker)

A: Automatic Defrost

M: Manual Defrost

P: Partial Automatic Defrost

AV[122] = Adjusted Volume

[122] Adjusted Volume (AV) can be found for ENERGY STAR® certified refrigerators on their website under the "advanced view" option. https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Refrigerators/p5st-her9. Scroll to the right until you reach the column named "Adjusted Volume".

Table C-24: Formulas to Calculate the ENERGY STAR® Refrigerator Criteria[123]

Product Category	Federal Standard as of Sept 15, 2014 Standard (kWh/year)	Maximum ENERGY STAR® Energy Usage (kWh/year)[124]	Ice (Y/N)	Defrost	Average Adjusted Volume[125]	kWh	kW
Refrigerator-only—manual defrost	6.79 × AV + 193.6	6.111 × AV + 174.24	Y, N	M	20.8	33.48	0.00772
Refrigerator-freezers—manual or partial automatic defrost	7.99 × AV + 225.0	7.191 × AV + 202.5	Y, N	M, P	24.51	42.08	0.00970
Refrigerator-only—automatic defrost	7.07 × AV + 201.6	6.363 × AV + 181.44	Y, N	A	15.75	31.30	0.00721
Built-in refrigerator-only—automatic defrost	8.02 × AV + 228.5	7.218 × AV + 205.65	Y, N	A	16.97	36.46	0.00840
Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	8.85 × AV + 317.0	7.965 × AV + 285.3	N	A	18.36	47.95	0.01105
Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	9.40 × AV + 336.9	8.46 × AV + 378.81	N	A	17.57	58.43	0.01347
Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without TTD ice service	8.85 × AV + 401.0	7.965 × AV + 360.9	N	A	24.6	61.87	0.01426

[123] Available for download at http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

[124] Ten percent more efficient than baseline, as specified in the ENERGY STAR® appliance calculator.

[125] This is the average volume of Energy Star qualified units for each configuration, based on the dataset located at: https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Refrigerators/p5st-her9/data

Product Category	***Federal Standard as of Sept 15, 2014 Standard (kWh/year)***	***Maximum ENERGY STAR® Energy Usage (kWh/year)***[124]	***Ice (Y/N)***	***Defrost***	***Average Adjusted Volume***[125]	***kWh***	***kW***
Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without TTD ice service	9.40 × AV + 420.9	8.46 × AV + 378.81	N	A	21.67	43.03	0.00992
Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	9.25 × AV + 475.4	8.325× AV + 427.86	Y	A	32.34	77.45	0.01785
Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker with TTD ice service	9.83 × AV + 499.9	8.847 × AV + 449.91	Y	A	21.67	71.29	0.01643
Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	8.51 × AV + 297.8	7.659 × AV + 268.02	N	A	30.44	55.68	0.01283
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	10.22 × AV + 357.4	9.198 × AV + 321.66	N	A	33.71	36.76	0.00847
Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	8.51 × AV + 381.8	7.659 × AV + 343.62	N	A	30.44	39.03	0.00900

Product Category	Federal Standard as of Sept 15, 2014 Standard (kWh/year)	Maximum ENERGY STAR® Energy Usage (kWh/year)[124]	Ice (Y/N)	Defrost	Average Adjusted Volume[125]	kWh	kW
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	10.22 × AV + 441.4	9.198 × AV + 397.26	N	A	34.06	78.95	0.01820
Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	8.54 × AV + 432.8	7.686 × AV + 389.52	Y	A	33.06	71.51	0.01648
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	10.25 × AV + 502.6	9.225 × AV + 452.34	Y	A	33.6	84.70	0.01952
Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	8.07 × AV + 233.7	7.263 × AV + 210.33	N	A	17.8	37.73	0.00870
Built-in refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker	9.15 × AV + 264.9	8.235 × AV + 238.41	N	A	17.8	27.41	0.00632
Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic ice maker without TTD ice service	8.07 × AV + 317.7	7.263 × AV + 285.93	N	A	21.22	62.26	0.01435
Built-in refrigerator-freezers—automatic	9.15 × AV + 348.9	8.235 × AV + 238.41	N	A	21.22	129.91	0.02994

Product Category	Federal Standard as of Sept 15, 2014 Standard (kWh/year)	Maximum ENERGY STAR® Energy Usage (kWh/year)[124]	Ice (Y/N)	Defrost	Average Adjusted Volume[125]	kWh	kW
defrost with top-mounted freezer without an automatic ice maker with TTD ice service							
Refrigerator-freezers—automatic defrost with top-mounted freezer with TTD ice service	8.40 × AV + 385.4	7.56 × AV + 346.86	Y	A	21.22	56.36	0.01299

C.1.10.3. Estimated Useful Life (EUL)

According to the Department of Energy Technical Support Document,[126] the Estimated Useful Life of High Efficiency Refrigerators is 17 years.

C.1.10.4. Measure Savings Calculations

Deemed peak demand and annual energy savings should be calculated as shown below. Note that these savings calculations are different depending on whether the measure is replace-on-burnout or early retirement.

C.1.10.4.1. Energy Savings

C.1.10.4.1.1. Replace-on-Burnout

$$kWh_{savings} = kWh_{baseline} - kWh_{ES}$$

Where:

$kWh_{baseline}$ = Federal standard baseline average energy usage (Table C-24)

kWh_{ES}= ENERGY STAR® average energy usage (Table C-24)

C.1.10.4.1.2. Early Retirement

Annual kWh and kW savings must be calculated separately for two time periods:

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[126] U.S. DOE 2011, Technical Support Document: "Residential Refrigerators, Refrigerator-Freezers, and Freezers, 8.2.3 Product Lifetimes." September 15. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

The estimated remaining life of the equipment that is being removed, designated the remaining useful life (RUL), and

The remaining time in the EUL period (17 – RUL)

For the RUL (Table C-25):

$$kWh_{savings} = kWh_{pre} - kWh_{ES}$$

kWh_{pre} refers to manufacturer data or a measured consumption that is adjusted using applicable degradation factors.

$$kWh_{pre} = kWh_{manf} \times (1 + \mathrm{PDF})^{n}\ x\ SLF$$

For the remaining time in the EUL period:

Calculate annual savings as you would for a replace-on-burnout project using the equation below. Lifetime kWh savings for Early Retirement Projects is calculated as follows:

$$Lifetime\ kWh_{savings} = \left(kwh_{savings,ER} \times RUL\right) + \left[kWh_{savings,ROB} \times (EUL - RUL)\right]$$

Where:

kWh_{NAECA}= NAECA baseline average energy usage (Table C-24)

kWhpre = Adjusted manufacturer energy usage

kWh_{ES} = ENERGY STAR® average energy usage (Table C-24)

kWh_{manf} = annual unit energy consumption from the Association of Home Appliance Manufacturers (AHAM) refrigerator database[127]

PDF = Performance Degradation Factor 0.0125/year. Refrigerator energy use is expected to increase at a rate of 1.25% per year as performance degrades over time[128]

n = age of replaced refrigerator (years)

SLF = Site/Lab Factor = 0.81 to account for the difference between DOE laboratory testing and actual conditions[129]

RUL = Remaining Useful Life (Table C-25)

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[127] AHAM Refrigerator Database. http://rfdirectory.aham.org/AdvancedSearch.aspx.

[128] 2009 Second Refrigerator Recycling Program NV Energy – Northern Nevada Program Year 2009; M&V, ADM, Feb 2010, referencing Cadmus data on a California program, February 2010.

[129] Peterson, J, et. al., 2007, “Gross Savings Estimation for Appliance Recycling Programs: The Lab Versus In Situ Measurement Imbroglio and Related Issues” International Energy Program Evaluation Conference (IEPEC). Cadmus, et. al. “Residential Retrofit High Impact Measure Evaluation Report.” February 8, 2010.

EUL = Estimated Useful Life = 17 years

C.1.10.4.2. Demand Savings

Since refrigerators operate 24/7, average kW reduction is equal to annual kWh divided by 8,760 hours per year. As shown below, this average kW reduction is multiplied by temperature and load shape adjustment factors to derive peak period kW reduction.

$$kW_{savings} = \frac{kWh_{savings}}{8{,}760\ hrs} \times \mathrm{TAF} \times \mathrm{LSAF}$$

Where:

TAF = Temperature Adjustment Factor[130] = 1.188

LSAF = Load Shape Adjustment Factor[131] = 1.074

C.1.10.4.3. Derivation of RULs

ENERGY STAR® Refrigerators have an estimated useful life of 17 years. This estimate is consistent with the age at which 50 percent of the refrigerators installed in a given year will no longer be in service, as described by the survival function in Figure C-2.

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[130] Proctor Engineering Group, Michael Blasnik & Associates, and Conservation Services Group, 2004, *"Measurement & Verification of Residential Refrigerator Energy Use: Final Report – 2003-2004 Metering Study"*. July 29. Factor to adjust for varying temperature based on site conditions, p. 47.

[131] Proctor Engineering Group, Michael Blasnik & Associates, and Conservation Services Group, 2004, "Measurement & Verification of Residential Refrigerator Energy Use: Final Report – 2003-2004 Metering Study". July 29. Used load shape adjustment for "hot days" during the 4PM hour, pp. 45-48.

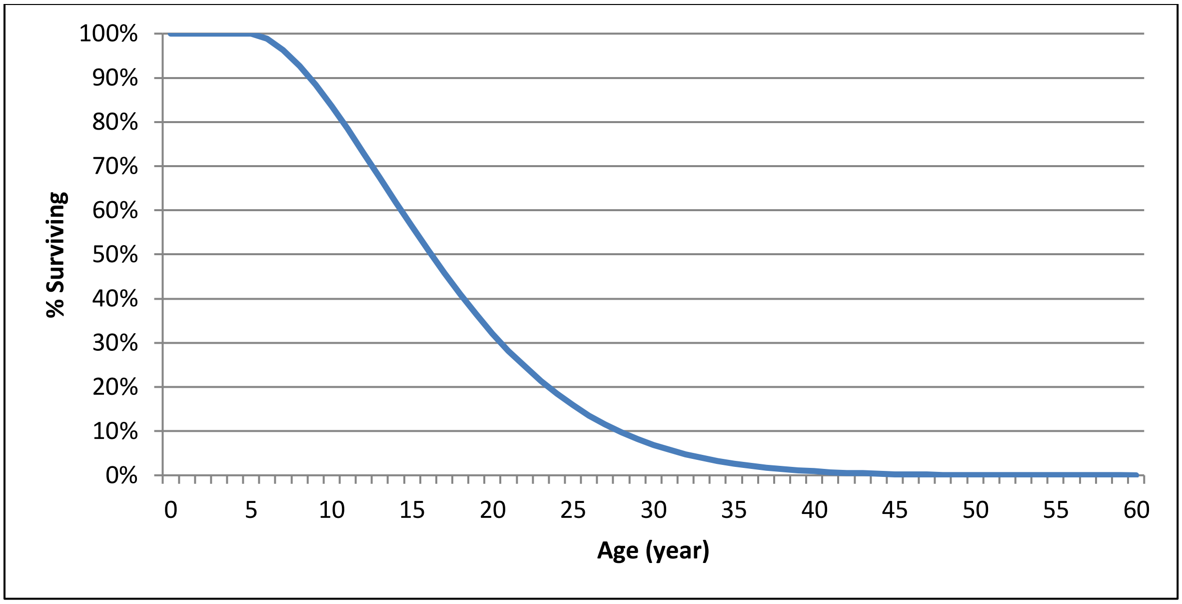

Figure 9: Survival Function for ENERGY STAR® Refrigerators[132]

The method for estimating the RUL of a replaced system uses the age of the existing system to re-estimate the projected unit lifetime based on the survival function shown in Figure C-2. The age of the refrigerator being replaced is found on the horizontal axis, and the corresponding percentage of surviving refrigerators is determined from the chart. The surviving percentage value is then divided in half, creating a new estimated useful lifetime applicable to the current unit age. The age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced.

Table C-25: Remaining Useful Life (RUL) of Replaced Refrigerator[133]

Age of Replaced Refrigerator (years)	***RUL (years)***	***Age of Replaced Refrigerator (years)***	***RUL (years)***
6	10.3	15	6.0
7	9.6	16	5.8
8	8.9	17	5.5
9	8.3	18	5.3
10	7.8	19	5.1
11	7.4	20	4.9

[132] U.S. DOE, Technical Support Document, 2011, "Residential Refrigerators, Refrigerator-Freezers, and Freezers, 8.2.3 Product Lifetimes." September 15. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

[133] Use of the early retirement baseline is capped at 22 years, representing the age at which 75 percent of existing equipment is expected to have failed. Equipment older than 22 years should use the ROB baseline.

12	7.0	21	4.8
13	6.6	22	4.6
14	6.3	23 +	0.0

C.1.10.5. Incremental Cost

The incremental cost for efficient refrigerators is $40[134] for ENERGY STAR units and $140[135] for CEE Tier II units.

For early retirement, incremental cost is calculated using:

1) Full installed cost of the refrigerator: program-actual purchase price should be used. If not available, use $451 for ENERGY STAR and $551 for CEE Tier 2 units[136].
2) Present value of replacement cost of a baseline refrigerator after the RUL of the initial replaced unit is exhausted. This unit costs $411[137] at the time of purchase, and should be discounted by the number of years of RUL. If RUL is unknown, use 4 years. Default discount rate is 10%[138]. This results in a deferred replacement cost of $281.
3) Overall incremental cost of early retirement is then calculated as:
    a. ENERGY STAR: $451 - $281 = $70
    b. CEE Tier II: $170

C.1.10.6. Net-to-Gross Ratio

The NTGR for this measure is 44%[139].

C.1.10.7. Future Studies

At the time of authorship of the New Orleans TRM Version 1.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation

[134] From ENERGY STAR appliance calculator

[135] Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in Department of Energy, "TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers", October 2005; http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf

[136] Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in Department of Energy, "TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers", October 2005; http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf

[137] Calculated by subtracting $40 incremental cost for ENERGY STAR refrigerators off of full purchase price of $451.

[138] "Participant Discount Rate" recommended in CA Standard Practice Manual.

[139] Based on primary data collection from 44 PY6-9 program participants.

should include a review of actual efficiency levels and costs of units purchased by New Orleans residents.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

C.1.11. ENERGY STAR® Freezers

C.1.11.1. Measure Description

This measure is for the purchase a freezer meeting the efficiency specifications of ENERGY STAR® is installed in place of a model meeting the federal standard (NAECA). An ENERGY STAR® freezer must be at least 10 percent more efficient than the minimum federal government standard.

C.1.11.2. Baseline and Efficiency Standards

The baseline equipment is assumed to be a model that meets the federal minimum standard for energy efficiency. The efficient equipment is defined as a freezer meeting the efficiency specifications of ENERGY STAR®, as defined below:

Table C-26. ENERGY STAR® Specifications

Equipment	***Volume***	***Criteria***
Full Size Freezer	7.75 cubic feet or greater	At least 10% more energy efficient than the minimum federal government standard (NAECA).
Compact Freezer	Less than 7.75 cubic feet and 36 inches or less in height	At least 20% more energy efficient than the minimum federal government standard (NAECA).

The standard varies depending on the size and configuration of the freezer (chest freezer or upright freezer, automatic or manual defrost) and is defined in the table below.

Energy usage specifications are defined in the table below (note, AV is the freezer Adjusted Volume and is calculated as 1.73*Total Volume):

Table C-27. Energy Usage Specifications

Product Category	***Volume (cubic feet)***	***Assumptions after September 2014***	
		Federal Baseline Maximum Energy Usage in kWh/year[140]	***ENERGY STAR Maximum Energy Usage in kWh/year***[141]
Upright Freezers with Manual Defrost	7.75 or greater	5.57*AV + 193.7	5.01*AV + 174.3
Upright Freezers with Automatic Defrost	7.75 or greater	8.62*AV + 228.3	7.76*AV + 205.5
Chest Freezers and all other Freezers except Compact Freezers	7.75 or greater	7.29*AV + 107.8	6.56*AV + 97.0
Compact Upright Freezers with Manual Defrost	< 7.75 and 36 inches or less in height	8.65*AV + 225.7	7.79*AV + 203.1

[140] See Department of Energy Federal Standards.
[141] See Version 5.0 ENERGY STAR specification.

Compact Upright Freezers with Automatic Defrost	< 7.75 and 36 inches or less in height	10.17*AV + 351.9	9.15*AV + 316.7
Compact Chest Freezers	<7.75 and 36 inches or less in height	9.25*AV + 136.8	8.33*AV + 123.1

C.1.11.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 22 years[142].

C.1.11.4. Calculation of Deemed Savings

C.1.11.4.1. Energy Savings

$$kWh_{savings} = kWh_{base} - kWh_{efficient}$$

Where:

kWh_{base} = Baseline kWh consumption per year as calculated in algorithm provided in table above.

$kWh_{efficient}$ = ENERGY STAR® kWh consumption per year as calculated in algorithm provided in table above.

C.1.11.4.2. Demand Savings

Demand savings should be calculated using the following formula:

$$kW_{savings} = kWh_{savings} \times Energy\ Demand\ Factor$$

Where:

$Energy\ Denamd\ Factor$ = 0.0001614[143]

[142] Based on 2011 DOE Rulemaking Technical Support Document, as recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.

[143] Consistent with the conversion factors in the Mid-Atlantic, Illinois, and Wisconsin TRMs. Derived from: (Temperature Adjustment Factor × Load Shape Adjustment Factor)/8760 hours. The temperature adjustment factor is 1.23 and is based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47) and assuming 78% of refrigerators are in cooled space (based on BGE Energy Use Survey, Report of Findings, December 2005; Mathew

C.1.11.5. Deemed Savings

Table C-28. Deemed Energy Savings and Demand Reductions

Freezer Category	***Average Unit Adj. Volume (ft³)***	***Conventional Usage (kWh/yr)***	***ENERGY STAR Usage (kWh/yr)***	***kWh Savings***	***kW Reduction***
Upright Freezers with Manual Defrost	27.9	349.1	314.1	35.0	0.0057
Upright Freezers with Automatic Defrost	27.9	468.8	422.0	46.8	0.0076
Chest Freezers and all other Freezers except Compact Freezers	27.9	310.4	280.0	30.3	0.0049
Compact Upright Freezers with Manual Defrost	10.4	315.7	284.1	31.5	0.0051
Compact Upright Freezers with Automatic Defrost	10.4	457.7	411.3	46.4	0.0075
Compact Chest Freezers	10.4	233.0	209.7	23.3	0.0038

C.1.11.6. Incremental Cost

The incremental cost for this measure is $42[144].

[144] Based on review of data from the Northeast Regional ENERGY STAR Consumer Products Initiative; "2009 ENERGY STAR Appliances Practices Report", submitted by Lockheed Martin, December 2009. Adjusted for inflation using https://www.usinflationcalculator.com .

C.1.12. Refrigerator and Freezer Recycling

C.1.12.1. Measure Description

This measure involves early retirement and recycling of an inefficient but operational existing, full-size (7.75 ft^3 or greater) refrigerator/freezer in a residential application. Savings represent the entire estimated energy consumption of the existing unit and are applicable over the estimated remaining life of the existing unit. A part use factor is applied to account for those secondary units that are not in use throughout the entire year.

C.1.12.2. Baseline and Efficiency Standards

Without program intervention, the recycled refrigerator or freezer would have remained operable on the electrical grid. As a result, the baseline condition for early retirement programs is the status quo (continued operation) and the basis for estimating energy savings is the annual energy consumption of the refrigerator or freezer being retired.

C.1.12.3. Estimated Useful Life (EUL)

It is difficult to determine the number of years that a recycled refrigerator would have continued to operate absent the program and, therefore, the longevity of the savings generated by recycling old-but-operable refrigerators through the program. According to the Department of Energy Technical Support Document,145 the Estimated Useful Life of High Efficiency Refrigerators is 17 years. The estimated EUL for a freezer is 12 years.[146] Section C.1.12.3.1of the New Orleans TRM details a survival analysis and the derivation of refrigerator and freezer RULs. Below, Table C-29 has been taken from said section and presents RULs by refrigerator or and freezer age.

[145] U.S. DOE 2011, Technical Support Document: "Residential Refrigerators, Refrigerator-Freezers, and Freezers, 8.2.3 Product Lifetimes." September 15. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

[146] ENERGY STAR® https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

Table C-29: Remaining Useful Life (RUL) of Replaced Refrigerator[147]

Age of Replaced Refrigerator (years)	Refrigerator RUL (years)	Freezer RUL (years)
6	10.3	7.3
7	9.6	6.8
8	8.9	6.3
9	8.3	5.9
10	7.8	5.5
11	7.4	5.2
12	7	4.9
13	6.6	4.7
14	6.3	4.4
15	6	4.2
16	5.8	4.1
17	5.5	3.9
18	5.3	0
19	5.1	0
20	4.9	0
21	4.8	0
22	4.6	0
23 +	0	0

If refrigerator or freezer age is unknown, use a measure life of 6 years[148] for refrigerators, 4 years for freezers.

C.1.12.3.1. Derivation of RULs

The Department of Energy Technical Support Document,[149] estimates that high efficiency refrigerator useful life is 17 years. This estimate is consistent with the age at which 50 percent of the refrigerators installed in a given year will no longer be in service, as described by the survival function in Figure C-2.

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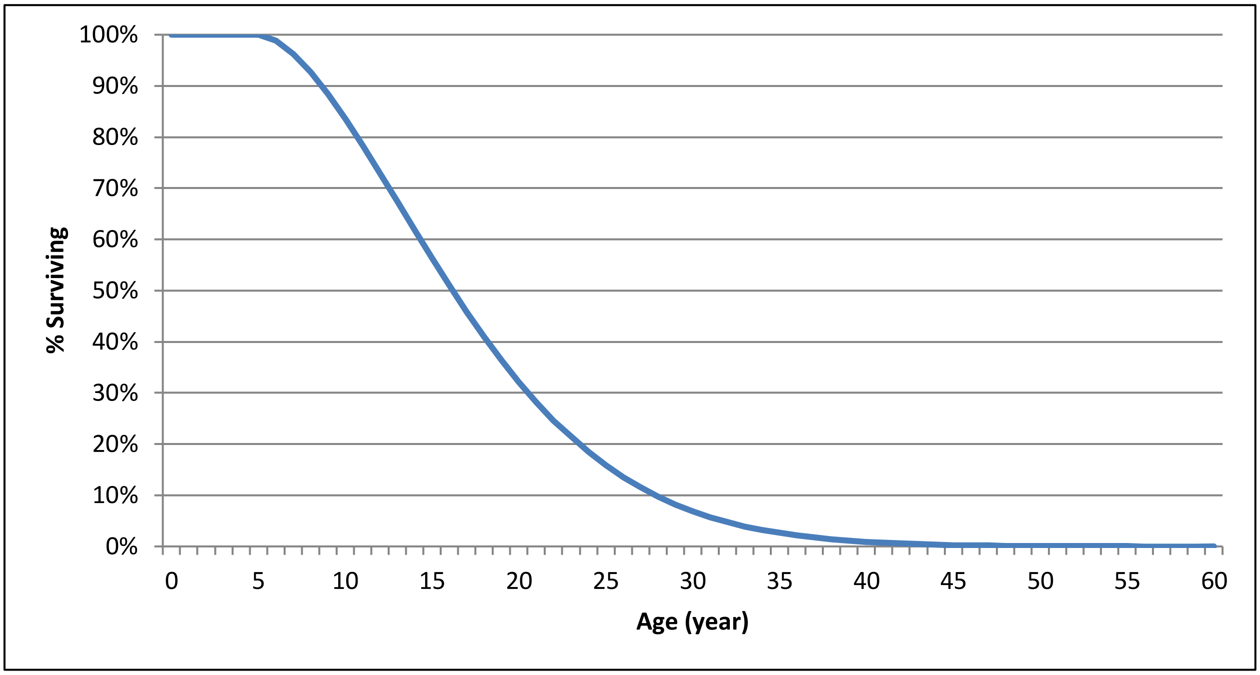
[147] Use of the early retirement baseline is capped at 22 years, representing the age at which 75 percent of existing equipment is expected to have failed. Equipment older than 22 years should use the ROB baseline.

[148] Rounded value from RUL table. Average all EULs, 6.34, rounded to 6.0.

[149] U.S. DOE 2011, Technical Support Document: "Residential Refrigerators, Refrigerator-Freezers, and Freezers, 8.2.3 Product Lifetimes." September 15. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

Figure C-2: Survival Function for ENERGY STAR® Refrigerators[150]



The method for estimating the RUL of a replaced system uses the age of the existing system to re-estimate the projected unit lifetime based on the survival function shown in Figure C-2. The age of the refrigerator being replaced is found on the horizontal axis, and the corresponding percentage of surviving refrigerators is determined from the chart. The surviving percentage value is then divided in half, creating a new estimated useful lifetime applicable to the current unit age. The age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced. To scale freezer RULs the TPE multiplied refrigerator RULs by the ratio of freezer/refrigerator EULs (12/17 = 0.706).

C.1.12.4. Energy and Demand Savings

Energy savings and demand reductions for retired refrigerators and freezers are based upon a linear regression model using equations and coefficients listed below.

C.1.12.4.1. Energy Savings

C.1.12.4.1.1. Refrigerators

Table C-30 displays the model coefficients and default inputs in the absence of program data. The coefficients presented are a combination of estimates from NREL, Illinois TRM

[150] U.S. DOE, Technical Support Document, 2011, "Residential Refrigerators, Refrigerator-Freezers, and Freezers, 8.2.3 Product Lifetimes." September 15. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43.

Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128.

V7.0, Texas TRM V6.0, and MidAtlantic TRM V8.0. Certain characteristics are 0-1 dummy indicators (such as whether a unit has side-by-side configuration). For these inputs, the Default Input is reflective of the average prevalence of that configuration the NREL UMP. For example, a default input of .323 for side-by-side indicates that 32.3% of units recycled could be expected to be side-by-side, based on prior research cited by the TPE.

Table C-30: Savings Coefficients for Refrigerator Savings

Independent Variable	***Estimated Coefficient[3]***	***Default Input[151]***	***kWh Impact***
Intercept	0.750	1	273.75
Age (years)	0.032	17.10	199.73
Pre-1990	1.140	.081	33.70
Size (square feet)	0.067	19.00	464.65
Single Door	-1.085	.039	-15.44
Side-by-Side	0.957	.323	112.83
Primary Usage	0.477	.696	121.18
Unconditioned x CDD	0.007	.259*3,470	6.29
Unconditioned x HDD	-0.016	.259*1,058	-4.38
Total Unit Energy Consumption			1,192
Part-Use Adjustment			93.2%
Default kWh Savings			1,111

$$\begin{aligned}\text{Savings}_{kWh} = {} & [0.75 + (Age \times 0.032) + (Pre-1990 \ \times 1.140) + (Size \ \times 0.067) \\ & + (Single\ Door \times \ -1.085) + (Side-by-Side \times 0.957) \\ & + (Primary\ Usage \times 0.477) + (Unconditioned\ CDD \ \times \ 0.007) \\ & + (Unconditioned\ HDD \times -0.016)] \times 365.25 \times 0.932\end{aligned}$$

Where:

Age = Age of retired unit

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)

Size = Capacity (cubic feet) of retired unit

Single Door = Single door dummy (=1 if one door, else 0)

Side-by-Side = Side-by-side dummy (= 1 if side-by-side, else 0)

Primary Usage = Primary usage type (in absence of the program) dummy (= 1 if Primary, else 0)

[151] Unit inputs based on averages from Public Service Company of New Mexico 2016 EM&V Report, ADM Associates Inc. Weather inputs based on TMY3 estimates for CDD and HDD for New Orleans). https://www.pnm.com/documents/396023/3157050/2016+Independent+Measurement+and+Verification+Report%2C%20Part+1%2C%20ADM+Associates%2C%20Inc.pdf/011b6c03-4358-4396-acf8-73cd8a24009e

Unconditioned x CDD = Weather interaction for units located in unconditioned spaces (=1*CDD). New Orleans CDD base 65 = 3,470[152]

Unconditioned x HDD = Weather interaction for units located in unconditioned spaces (=1*HDD) New Orleans HDD base 65 = 1,058[3]

Part Use = To account for those units that are not running throughout the entire year.

For example: A resident decides to recycle a 20 square foot single door, non-side-by-side refrigerator. They originally purchased the unit in 1995 and has since been replaced, so this unit is now located in an unconditioned garage as extra food and beverage storage.

$$\text{Savings}_{kWh} = [0.75 + (24 \times 0.032) + (0 \times 1.140) + (20 \times 0.067) + (1 \times -1.085) + (0 \times 0.957) + (0 \times 0.477) + (1 \times 0.007) + (1 \times -0.016)] \times 365.25 \times 0.932$$

= 600.49 kWh

C.1.12.4.1.2. Freezers

Table C-31: Savings Coefficients for Freezer Savings

Independent Variable	***Estimated Coefficient[153]***	***Default Input***	***kWh Impact***
Intercept	-0.296	1	-108.04
Appliance Age (years)	0.039	17.1	243.42
Pre-1990	0.486	0.081	14.37
Size (square feet)	0.104	15.9	603.56
Freezer Chest	0.122	0.119	5.30
Unconditioned x CDD	-0.002	.741*3470	-5.14
Unconditioned x HDD	0.024	.741*1,058	18.82
Total Unit Energy Consumption			772
Part-Use Adjustment			85.5%
Default kWh Savings			660

$$\text{Savings}_{kWh} = [-0.296 + (Age \times 0.039) + (Pre - 1990 \times 0.486) + (Size \times 0.104) + (Freezer\ Chest \times 0.122) + (Unconditioned\ CDD \times -0.002) + (Unconditioned\ HDD \times 0.024)] \times 365.25 \times 0.855$$

Where:

Freezer Chest = Chest freezer dummy (= 1 if chest freezer, else 0)

[152] Calculated using New Orleans TMY3 data.

[153] The coefficients presented are a combination of estimates from NREL, Illinois TRM V7.0, Texas TRM V6.0, and MidAtlantic TRM V8.0.

C.1.12.4.2. Demand Savings

$$\text{Savings}_{kW} = \left(\frac{\Delta kWh}{8{,}760}\right) \times CF$$

Where:

CF = Coincident factor defined as summer kW/average kW
= 1.082 for Refrigerators
= 1.065 for Freezers

The coincident factor aggregates two adjustments:

1. The duty cycle of the equipment during the peak period; and
2. The declining efficiency of the compressor when subject to higher outside air temperatures.

The resulting aggregate effect is a coincidence factor > 1.0 for refrigerators and freezers.

Based on the default inputs specified in Table C-30 and Table C-31, the recommended default kW values are:

- Refrigerators: 1,111 / 8,760 * 1.082 = .0137
- Freezers: 660 / 8,760 * 1.065 = .080

C.1.12.5. Incremental Cost

The incremental cost for this measure is the actual cost associated with the removal and recycling of the secondary refrigerator. If unknown, use $170 per unit[154].

C.1.12.6. Future Studies

This chapter is based on regression coefficients averaged from NREL, the Illinois TRM 7.0, the Texas TRM 6.0 and the Mid-Atlantic TRM 8.0 and citation of unit data from a refrigerator recycling evaluation completed on behalf of Public Service Company of New Mexico. It is recommended that program administrators collect the data needed to support energy savings estimates based on actual units recycled. Administrators should collect:

a. Unit age;
b. Size (cubic feet);

[154] Illinois TRM v7.0 Vol. 3, page 37. The $170 default assumption is based on $120 cost of pickup and recycling per unit and $50 proxy for customer transaction costs and value customer places on their lost amenity. $120 is cost of pickup and recycling based on similar Efficiency Vermont program. $50 is bounty, based on Ameren and ComEd program offerings as of 7/27/15.

c. Configuration (Refrigerators: side-by-side, single-door, top-freezer, bottom-freezer. Freezers: upright, chest);

d. Location of use (conditioned versus unconditioned space); and

e. Unit make and model number.

A net-to-gross study will be required, which will address the extent to which the units would have been disposed of by program participants in the absence of the program; free-ridership for refrigerator recycling addresses the question of “would the unit be plugged in in the absence of a program intervention”, and as a result the savings are program attributable if a participation would have otherwise kept it in use, gave it to a friend or relative, donated it to charity, or sold the unit.

If refrigerator/freezer cycling constitutes 5% or more of portfolio-level residential savings, the TPE would recommend an *in-situ* metering study to develop a New Orleans-specific unit energy consumption regression model.

C.2. Domestic Hot Water

C.2.1. Water Heater Replacement

C.2.1.1. Measure Description

This measure involves:

- The replacement of electric water heaters by ENERGY STAR® heat pump water heaters (HPWH);
- The replacement of either electric or gas water heaters by ENERGY STAR certified solar water heaters.

Systems greater than 55 gallons in capacity have an efficiency requirement that necessitates installation of a heat pump water heater or tank-less system.

Water heating deemed savings values are measured on an annual per-unit basis. Deemed savings variables include tank volume, estimated water usage, and rated uniform energy factor. Fuel substitution is not eligible for deemed savings. This measure applies to all residential applications.

C.2.1.2. Baseline and Efficiency Standards

The current baseline for electric and gas water heaters is the US DOE energy efficiency standard (10 CFR Part 430), which is consistent with the International Energy Conservation Code (IECC) 2009. Residential water heaters manufactured on or after April 16, 2015 must comply with the amended standards found in the Code of Federal Regulations, 10 CFR 430.32(d)[155]. An abbreviated account of the regulations that apply to qualifying water heater units are found in Table C-8.

[155] https://www.govinfo.gov/content/pkg/CFR-2018-title10-vol3/pdf/CFR-2018-title10-vol3-part430.pdf (pg. 480)

Table C-32: Title 10: 430.32 (d) Water Heater Standards

Product Class	**Rated Storage Volume**	**Draw Pattern**	**Uniform Energy Factor (UEF)**
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 – (0.0008 × Vr)
		Low	0.9254 – (0.0003 × Vr)
		Medium	0.9307 – (0.0002 × Vr)
		High	0.9349 – (0.0001 × Vr)
	> 55 gal and ≤ 120 gal	Very Small	1.9236 – (0.0011 × Vr)
		Low	2.0440 – (0.0011 × Vr)
		Medium	2.1171 – (0.0011 × Vr)
		High	2.2418 – (0.0011 × Vr)
Instantaneous Electric Water Heater (tankless)	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92
Where Vr[156] is the Rated Storage Volume which equals the water storage capacity of a water heater, in gallons, as certified by the manufacturer.			

The new code requires that a "draw pattern" is to be determined to better calculate the energy factor associated with a water heater. The draw pattern is based on the first hour rating (FHR) of an installed water heater and is defined as the number of gallons of hot water the heater can supply per hour. The following three tables (Table C-33, Table C-34, and Table C-35) provide the FHR ranges and corresponding draw patterns for different equipment types.

Table C-33: Tank Water Heater Draw Pattern

New FHR Greater Than or Equal to:	**New FHR Less Than:**	**Draw pattern**
0 gallons	18 gallons	Very Small
18 gallons	51 gallons	Low
51 gallons	75 gallons	Medium
75 gallons	No Upper Limit	High

Table C-34: Instantaneous Water Heater Draw Pattern

New Max GPM Greater Than or Equal to:	**New Max GPM Rating Less Than:**	**Draw pattern**
0 gallons/minute	1.7 gallons/minute	Very Small
1.7 gallons/minute	2.8 gallons/minute	Low
2.8 gallons/minute	4 gallons/minute	Medium
4 gallons/minute	No Upper Limit	High

[156] Vr is the Rated Storage Volume (in gallons), as determined pursuant to 10 CFR 429.17

Table C-35: Heat Pump Water Heater Draw Pattern

Draw Volume	**Draw Pattern**
10 gallons	Very Small
38 gallons	Low
55 gallons	Medium
84 gallons	High

Current baseline Uniform Energy Factors (efficiencies) for various tank size electric storage water heaters are calculated and shown in Table C-36. The estimated annual hot water usage for electric storage water heaters of various sizes are shown in Table C-37.

Table C-36: Calculated Electric Storage Water Heater Baseline Uniform Energy Factors

Uniform Energy Factors by Tank Size		**Capacity (Gallons)**				
		30	**40**	**50**	**65**	**80**
		≥ 20 gal and ≤ 55 gal			**> 55 gal and ≤ 120 gal**	
Electric Storage Water Heater	Very Small	0.8568	0.8488	0.8408	1.8521	1.8356
	Low	0.9164	0.9134	0.9104	1.9725	1.956
	Medium	0.9247	0.9227	0.9207	2.0456	2.0291
	High	0.9319	0.9309	0.9299	2.1703	2.1538

Table C-37: Estimated Annual Hot Water Use (gal)

Tank Size (gal) of Replaced Water Heater	**30**	**40**	**50**	**65**	**80**
Estimated Annual Hot Water Usage	12,761	16,696	18,973	22,767	27,320

C.2.1.3. Estimated Useful Life (EUL)

The average lifetime of this measure is dependent on the type of water heating. According to DEER 2014, the following measure lifetimes should be applied:

- 13 years for electric storage tank water heaters
- 10 years for Heat Pump Water Heaters
- 20 years for tank-less electric water heaters
- 15 years for solar water heaters

C.2.1.4. Deemed Energy Savings and Demand Reductions

Calculated deemed energy savings are shown in Table C-38. Water heater replacements that have tank sizes that fall between the range of 30-gallon to 50-gallon in volume generally produce adequate energy savings.

Table C-38: Deemed kWh Savings for Water Heater Replacement

Water Heater System Type	HVAC System Type	Draw Pattern	Capacity (Gallons)				
			30	40	50	65	80
Heat Pump Water Heater	Gas Furnace	Very Small	1,351	1,790	2,059	709	867
		Low	1,236	1,624	1,854	620	757
		Medium	1,221	1,602	1,826	570	697
		High	1,208	1,583	1,801	494	605
	Heat Pump	Very Small	1,220	1,618	1,864	475	586
		Low	1,105	1,452	1,658	386	477
		Medium	1,090	1,430	1,631	336	417
		High	1,077	1,411	1,606	260	324
	Electric Resistance	Very Small	1,130	1,501	1,731	315	394
		Low	1,015	1,335	1,525	226	285
		Medium	1,000	1,313	1,497	177	225
		High	987	1,294	1,473	100	132
	Unconditioned	Very Small	1,260	1,670	1,923	546	671
		Low	1,144	1,504	1,718	457	562
		Medium	1,130	1,483	1,690	408	502
		High	1,117	1,464	1,666	331	409
Solar with Electric Backup	N / A	Very Small	1,611	2,130	2,446	1,173	1,423
		Low	1,496	1,964	2,240	1,083	1,314
		Medium	1,481	1,942	2,212	1,034	1,254
		High	1,468	1,923	2,188	958	1,161

Calculated deemed demand reductions are shown in Table C-39.

Table C-39: Deemed kW Savings for Water Heater Replacement

Water Heater System Type	HVAC System Type	Draw Pattern	Capacity (Gallons)				
			30	40	50	65	80
Heat Pump Water Heater	Gas Furnace	Very Small	0.1185	0.1570	0.1806	0.0622	0.0760
		Low	0.1084	0.1424	0.1626	0.0543	0.0664
		Medium	0.1071	0.1405	0.1601	0.0500	0.0612
		High	0.1060	0.1388	0.1580	0.0433	0.0530
	Heat Pump	Very Small	0.1070	0.1419	0.1635	0.0417	0.0514
		Low	0.0969	0.1274	0.1455	0.0338	0.0418
		Medium	0.0956	0.1254	0.1430	0.0295	0.0365
		High	0.0944	0.1238	0.1409	0.0228	0.0284
	Electric Resistance	Very Small	0.0991	0.1316	0.1518	0.0276	0.0345
		Low	0.0890	0.1171	0.1338	0.0198	0.0250
		Medium	0.0877	0.1152	0.1313	0.0155	0.0197
		High	0.0866	0.1135	0.1292	0.0088	0.0116
	Unconditioned	Very Small	0.1105	0.1465	0.1687	0.0479	0.0589
		Low	0.1004	0.1319	0.1507	0.0401	0.0493
		Medium	0.0991	0.1300	0.1482	0.0357	0.0440
		High	0.0979	0.1284	0.1461	0.0291	0.0359
Solar with Electric Backup	N / A	Very Small	0.1413	0.1868	0.2145	0.1029	0.1248
		Low	0.1312	0.1722	0.1965	0.0950	0.1152
		Medium	0.1299	0.1703	0.1940	0.0907	0.1100
		High	0.1288	0.1687	0.1919	0.0840	0.1018

C.2.1.5. Calculation of Deemed Savings – Heat Pump Water Heater (HPWH)

C.2.1.5.1. Energy Savings – HPWH

The residential heat pump water heater (HPWH) measure involves the installation of an integrated ENERGY STAR® HPWH. The HPWHs available through the ENERGY STAR product finder[157] have an average UEF of 3.22.

The variables affecting deemed savings are: storage tank volume, HPWH Energy Factor (EF), HPWH installation location (in conditioned or unconditioned space), and weather zone. This measure takes into account an air-conditioning energy savings (“Cooling Bonus”) and an additional space heating energy requirement (“Heating Penalty”) associated with the HPWH when it is installed inside conditioned space.

[157] www.energystar.gov/productfinder/product/certified-water-heaters/ accessed on 7/10/2019.

$$kWh_{Savings} = \frac{\rho \times C_p \times V \times (T_{SetPoint} - T_{Supply}) \times \left(\frac{1}{EF_{pre}} - \left(\frac{1}{(EF_{post} \times (1 + PA\%)} \times Adj\right)\right)}{3{,}412\ Btu/kWh}$$

Where:

ρ = Water density = 8.33 lb/gal

C_p = Specific heat of water = 1 BTU/lb.·°F

V = Estimated annual hot water use (gal) from Table C-37

$T_{SetPoint}$ = Water heater set point (value = 123.61°F, based on on-site testing of New Orleans homes)

T_{Supply} = Average New Orleans area supply water temperature, 74.8°F

EF_{pre} = Baseline Uniform Energy Factor from Table C-36

EF_{post} = Uniform Energy Factor of new HPWH. ENERGY STAR® average is 3.22[158]

$PA\%$ = Performance Adjustment to adjust the HPWH EF relative to ambient air temperature per DOE guidance[159] $= 0.00008 \times T_{amb}^3 + 0.0011 \times T_{amb}^2 - 0.4833 \times T_{amb} + 0.0857$. Assumed conditioned space, 73.4 degrees[160], PA% = 2.17%. For unconditioned space, 68.78 degrees[161], PA% = -1.92%

T_{amb}= Ambient temperature dependent on location of HPWH (Conditioned or Unconditioned Space) and Weather Zone from Table C-40

Adj =HPWH-specific adjustment factor to account for Cooling Bonus and Heating Penalty on an annual basis, as well as backup electrical resistance heating which is estimated at 0.92 EF. Adjustment factors are listed in Table C-41 .

$3{,}412\ Btu/kWh$ = conversion factor to convert BTU to kWh

The average ambient air temperatures listed in Table C-40 are applicable to the installation locations for the HPWH. Unconditioned space is considered to be an unheated garage-like environment. This data is based on local ambient temperatures for each weather zone calculated from TMY3 weather data. The conditioned space temperatures

[158] Based on an inventory of ENERGY STAR®-listed models in 2019.

[159] Kelso, J. 2003. Incorporating Water Heater Replacement into The Weatherization Assistance Program, May. D&R International, Ltd. Information Tool Kit.

[160] "Average daily outside temperature at which a building maintains a comfortable indoor temperature without heating or cooling"; www.weatherdatadepot.com/faq#.USPZwKWvN8E

[161] From NREL TMY3 database

assume thermostat settings of 78°F (cooling season) and 70°F (heating season), and a "balance point temperature"[162] of 65°F. Unconditioned space ambient temperatures are adjusted from the local temperatures by seasonal factors[163] to account for a garage-like setting.

Table C-40: Average Ambient Temperatures and PA% Factors by Installation Location

	Conditioned Space	***Unconditioned Space***
$T_{ambient}$	73.4°F	68.9°F
PA% Factor	2.17%	- 1.91%

Table C-41: HPWH Adjustment[164]

Water Heater Location	***Furnace Type***	***Adjustment Factor***
Conditioned Space	Gas	0.917
	Heat Pump	1.201
	Elec. Resistance	1.395
Unconditioned Space	N/A	1.07

As an example, the following deemed electricity savings are applicable for the replacement of a 50-gallon electric storage tank water heater having a medium draw pattern, with a 50-gallon heat pump water heater using an ENERGY STAR® model with an EF of 3.22 in conditioned space for a household using a gas furnace in New Orleans:

$$kWh_{Savings} = \frac{8.33 \times 1 \times 18{,}973 \times (123.61 - 74.8) \times \left(\frac{1}{0.9207} - \left(\frac{1}{3.22 \times (1 + 0.0217355)} \times 0.917\right)\right)}{3{,}412\ Btu/kWh}$$

$$= 1{,}825.758 kWh$$

C.2.1.5.2. Demand Savings – HPWH

$$kW_{savings} = kWh_{savings} \times Ratio^{Peak\ kW}_{Annual\ kWh}$$

162 "Average daily outside temperature at which a building maintains a comfortable indoor temperature without heating or cooling"; www.weatherdatadepot.com/faq#.USPZwKWvN8E

163 ASHRAE: Standard 152-2004 Table 6.1b and 6.2b

164 In order to facilitate an algorithmic approach: a spreadsheet model was created which modeled savings accounting for Cooling Bonus and Heating Penalty on an annual basis, as well as backup electrical resistance heating; HPWH Adjustment factors were derived to equate the results of this more extensive model to a simpler algorithm.

Where:

$Ratio_{Annual\ kWh}^{Peak\ kW}$ = 0.0000877

Demand savings were calculated using the US DOE's "*Building America Performance Analysis Procedures for Existing Homes*" combined domestic hot water use profile.[165] Based on this profile, the ratio of Peak kW to Annual kWh for domestic hot water usage was estimated to be 0.0000877 kW per annual kWh savings

For the HPWH example shown in equation above, peak demand savings is 1,826 kWh × 0.0000877 = 0.160 kW.

C.2.1.6. Calculation of Deemed Savings – Solar Water Heating with Electric Backup

C.2.1.6.1. Energy Savings – Solar Water Heating Systems with Electric Backup

The residential solar water heater measure involves the installation of an ENERGY STAR® certified solar water heater rated by the Solar Rating and Certification Corporation (SRCC). Solar water heaters available through the ENERGY STAR® product finder[166] have an average Solar Energy Factor (SEF) of 8.7 for electric backup.

The variables affecting deemed savings are: SEF, LF, and weather zone.

The SRCC determines SEF based on standardized 1,500 Btu/ft^2-day solar radiation profile across the U.S. As solar insolation varies widely depending on geographic location, in order to derive more accurate estimates for a given locale, Localization Factors (LF) are used to adjust the SEF. The LF for the New Orleans weather zone have been calculated. The LF is based on the daily total insolation (1,598 in New Orleans), averaged annually, per a Satellite Solar Radiation model developed by the State University of New York (SUNY).

$$kWh_{Savings} = \frac{\rho \times C_p \times V \times (T_{SetPoint} - T_{Supply}) \times \left(\frac{1}{EF_{pre}} - \frac{1}{SEF\ x\ LF}\right)}{3412\ Btu/kWh}$$

Where:

ρ = Water density = 8.33 lb./gal

C_p = Specific heat of water = 1 BTU/lb·°F

V = Estimated annual hot water use (gal) from Table C-37

[165] U.S. DOE "Building America Performance Analysis Procedures for Existing Homes" combined domestic hot water use profile.

[166] www.energystar.gov/productfinder/product/certified-water-heaters/results

$T_{SetPoint}$ = Water heater set point (default value = 122.24°F)
T_{Supply} = Average New Orleans area supply water temperature, 74.8°F
EF_{pre} = Baseline Energy Factor
SEF = Solar Energy Factor of new water heater, default of 8.7
LF = Localization Factor for SEF of new water heater in New Orleans, 1.068

As an example, the following deemed electricity savings are applicable for replacement of a 50-gallon (High Draw) electric storage tank water heater with a 50-gallon solar water heater with electric backup using a model with an EF of 8.7 for a household in New Orleans:

$$kWh_{Savings} = \frac{8.33 \times 1 \times 18{,}973 \times (123.61 - 74.8) \times \left(\frac{1}{0.9209} - \frac{1}{(8.7\ \times\ 1.068)}\right)}{3{,}412\ Btu/kWh}$$
$$= 2{,}212.30\ kWh/yr$$

C.2.1.6.2. Demand Savings – Solar Water Heating Systems with Electric Backup

$$kW_{savings} = kWh_{savings} \times Ratio \frac{Peak\ kW}{Annual\ kWh}$$

Where:

$Ratio \frac{Peak\ kW}{Annual\ kWh}$ = 0.0000877

For the above example, peak demand savings is 2,188.00 kWh x 0.0000877 = 0.194 kW.

C.2.1.7. Incremental Cost

Incremental costs are as follows.

Table C-42: Incremental Costs

	Size Category				
Replacement Type	**30**	**40**	**50**	**65**	**80**
Storage Tank - HPWH[167]	$582.99	$493.74	$404.37	$100.00	$138.38
Solar with Gas Back-up	$8,401[168]				

C.2.1.8. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure has been implemented in Energy Smart programs. However, participation for this measure is

[167] CA DEER Workpaper SWWH014 – HPWH Res. (2019)

[168] California Solar Thermal Program: 2012 reported project costs.

currently too low to create reliable averages of measure characteristics. As a result, savings are calculated using ENERGY STAR default values.

If participation reached 1% of residential Energy Smart program savings, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents and the TPE recommends a metering study to support usage assumptions. Further, the TPE recommends a review of sizing changes from baseline to post-retrofit and an assessment of whether there needs to be consideration of snapback effects in HPWH retrofits.

If the measure is under consideration for increased emphasis in Energy Smart, the TPE recommends a market assessment to provide guidance as to the needs of New Orleans residents and plumbing contractors and to address savings potential.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant.

C.2.2. Water Heater Jackets

C.2.2.1. Measure Description

This measure involves water heater jackets (WHJ) installed on water heaters located in an unconditioned space. These estimates apply to all weather regions. This measure applies to all residential applications.

C.2.2.2. Baseline and Efficiency Standards

Baseline is assumed to be the post-1991, storage-type water heater.

WHJ must be installed on storage water heaters having a capacity of 30 gallons or greater. The manufacturer's instructions on the WHJ and the water heater itself should be followed. If electric, thermostat and heating element access panels must be left uncovered. If gas, follow WHJ installation instructions regarding combustion air and flue access.

Table C-43: Water Heater Jackets – Baseline and Efficiency Standards

Baseline	Efficiency Standard
Un-insulated water heater	Minimum insulation of R-6.7

C.2.2.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 13 years, according to NEAT v.8.6.

C.2.2.4. Deemed Savings Values

Deemed savings are per installed jacket based on the jacket thickness, the type of water heating and the tank size.

Table C-44: Water Heater Jackets – Electric Heating Deemed Savings Values

	Electric Water Heating					
Approximate Tank Size (gal)	kWh Savings			kW Savings		
	40	52	80	40	52	80
2" WHJ savings kWh	68	76	101	0.005	0.006	0.008
3" WHJ savings kWh	94	104	139	0.007	0.008	0.011

C.2.2.5. Calculation of Deemed Savings

Energy consumption for baseline units, with and without insulation jackets, was calculated using industry-standard energy-use calculation methodologies for residential domestic water heating. Variables in the calculations include the following:

- Water heater fuel type (electric or gas/propane)
- Baseline EF
- Estimated U-value of baseline unit
- Ambient temperature

- Tank volume
- Tank surface area
- Tank temperature
- Estimated hot water consumption

To estimate peak energy consumption, a load profile for residential water heating was developed from individual load profiles for the following end-uses:

- Clothes washer
- Dishwasher
- Faucet
- Shower
- Sink-filling
- Bath
- Miscellaneous

This end-use load shape data was calibrated using metered end-used data obtained from several utility end-use metering studies.

C.2.2.6. Incremental Cost

The incremental cost of a Water Heater Jacket is equal to the full installed cost. If the cost is unknown, use $35[169].

C.2.2.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values based on NEAT v.8.6 estimates.

In the PY7 or PY8 evaluation of the Home Performance with Energy Star program, it is recommended that the percent of unjacketed water heaters is documented in order to inform whether water heater jackets warrant inclusion as a direct install measure.

[169] Based on review of available products for 40 and 50-gallon water heaters.

C.2.3. Water Heater Pipe Insulation

C.2.3.1. Measure Description

This measure requires water heater pipe insulation. Water heaters plumbed with heat traps are not eligible to receive incentives for this measure. New construction and water heater retrofits are not eligible for this measure, because they must meet current code requirements. This measure applies to all residential applications.

C.2.3.2. Baseline and Efficiency Standards

Baseline is assumed to be the typical gas or electric water heater with no heat.

All hot and cold vertical lengths of pipe should be insulated, plus the initial length of horizontal hot and cold water pipe, up to three feet from the transition, or until wall penetration, whichever is less.

Table C-45: Water Heater Pipe Insulation – Baseline and Efficiency Standards

Baseline	Efficiency Standard
Un-insulated hot water pipes	Minimum insulation thickness of ½”

C.2.3.3. Estimated Useful Life (EUL)

The average lifetime of this measure is dependent on the type of water heater it is applied to. According to DEER 2014, the following measure lifetimes should be applied:

- 13 years for electric storage water heating
- 11 years for gas storage water heating
- 10 years for heat pump water heaters

C.2.3.4. Deemed Savings Values

The deemed savings per linear foot are detailed below.

Table C-46: Pipe Wrap – Deemed Savings Per Linear Foot

R-value	Pipe Diameter	kWh	kW
3	½”	25.32	.0029
	¾”	37.99	.0043

C.2.3.5. Calculation of Deemed Savings

C.2.3.5.1. Energy Savings

$$Annual\ Energy\ Savings = (U_{pre} - U_{post}) \times A \times (T_{Pipe} - T_{ambient}) \times \left(\frac{1}{RE}\right) \times \frac{Hours_{Total}}{Conversion\ Factor}$$

Where:

U_{pre}= 1/(2.03[170]) = 0.49 BTU/h sq. ft. degree F

U_{post}= 1/(2.03+$R_{Insulation}$)

$R_{Insulation}$= R-value of installed insulation

A = Surface area in square feet (πDL) with L (length) and D pipe diameter in feet

T_{Pipe}(°F) = Average temperature of the pipe. Default value = 90 °F (average temperature of pipe between water heater and the wall)

$T_{ambient}$(°F) = 68.78°F (New Orleans)

RE = Recovery Efficiency (or in the case of HPWH, EF); if unknown, use 0.98 as a default for electric resistance water heaters, 0.79 for natural gas water heaters, or 2.2 for heat pump water heaters[171]

$Hours_{Total}$ = 8,760 hr per year[172,173]

$Conversion\ Factor$ = 3,412 Btu/kWh for electric water heating or 100,000 Btu/Therm for gas water heating.

C.2.3.5.2. Demand Savings

Peak demand savings for hot water heaters installed in conditioned space can be calculated using the following formula for electric:

$$kW_{savings} = (U_{pre} - U_{post}) \times A \times (T_{Pipe} - T_{ambientMAX}) \times \left(\frac{1}{RE}\right) \times \frac{1}{3{,}412\ Btu/kWh}$$

Where:

U_{pre} = 1/(2.03) =0.49 BTU/h sq ft degree F

U_{post} = 1/(2.03+$R_{Insulation}$)

[170] 2.03 is the R-value representing the film coefficients between water and the inside of the pipe and between the surface and air. Mark's Standard Handbook for Mechanical Engineers, 8th edition.

[171] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at https://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx

[172] Ontario Energy's Measures and Assumptions for Demand Side Management (DSM) Planning www.ontarioenergyboard.ca/OEB/_Documents/EB-2008-0346/Navigant_Appendix_C_substantiation_sheet_20090429.pdf

[173] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Residential, Multi-Family, and Commercial/Industrial Measures http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/06f2fee55575bd8a852576e4006f9af7/$FILE/TechManualNYRevised10-15-10.pdf

$R_{Insulation}$ = R-value of installed insulation

$A =$ Surface area in square feet (πDL) with L (length) and D pipe diameter in feet

$T_{Pipe}(°F) =$ Average temperature of the pipe. Default value = 90 °F (average temperature of pipe between water heater and the wall)

$T_{ambientMAX}(°F) =$For water heaters installed in unconditioned basements, use an average ambient temperature of 75°F; for water heaters inside the thermal envelope, use an average ambient temperature of 78 °F

RE = Recovery efficiency (or in the case of HPWH, EF); if unknown, use 0.98 as a default for electric resistance or 2.2 for heat pump water heaters.

C.2.3.6. Incremental Cost

The incremental cost of a Water Heater Pipe Insulation is equal to the full installed cost. If the cost is unknown, use $3 per linear foot of insulation[174].

C.2.3.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values based on NEAT v.8.6 estimates.

In the PY7 or PY8 evaluation of the Home Performance with Energy Star program, it is recommended that the percent of uninsulated hot water lines is documented in order to inform whether pipe insulation warrant inclusion as a direct install measure

[174] California DEER 2014

C.2.4. Faucet Aerators

C.2.4.1. Measure Description

This measure involves retrofitting aerators on kitchen and bathroom water faucets. The savings values are per faucet aerator installed. It is not a requirement that all faucets in a home be treated for the deemed savings to be applicable. This measure applies to all residential applications.

C.2.4.2. Baseline and Efficiency Standards

The 2.2 gallons per minute (GPM) baseline faucet flow rate[175] is based upon the Energy Policy Act of 1992 (EPAct 92) and subsequent EPAct actions which limited faucet flows to 2.2 GPM. The US EPA WaterSense® specification for faucet aerators is 1.5 GPM.[176]

Table C-47: Faucet Aerators – Baseline and Efficiency Standards

Baseline	***Efficiency Standard***
2.2 GPM	1.5 GPM maximum

The deemed savings values are for residential, retrofit-only installation of kitchen and bathroom faucet aerators.

C.2.4.3. Additional Requirement for Contractor-Installed Aerators

Aerators that have been defaced so as to make the flow rating illegible are not eligible for replacement. For direct install programs, all aerators removed shall be collected by the contractor and held for possible inspection by the utility until all inspections for invoiced installations have been completed.

C.2.4.4. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2014.

C.2.4.5. Deemed Savings

Table C-47 summarizes the deemed kWh and kW for 1.5 GPM and 1.0 GPM faucet aerators, based on the algorithms in the subsections to follow.

[175] Maximum flow rate federal standard for lavatories and aerators set in Federal Energy Policy Act of 1992 and codified at 2.2 GPM at 60 psi in 10CFR430.32

[176] "High-Efficiency Lavatory Faucet Specification." WaterSense. EPA. October 1, 2007. http://www.epa.gov/watersense/partners/faucets_final.html

Table C-48: Faucet Aerators – Deemed Savings

Efficient GPM Rating	Water Heater Type	kWh	kW
1.5 GPM	Electric Resistance	26.80	0.0028
	Heat Pump	11.94	0.0012
1.0 GPM	Electric Resistance	44.66	0.0046
	Heat Pump	19.90	0.0021

C.2.4.6. Effect of Weather Zones on Water Usage and Water Main Temperature

Average water main temperatures for the New Orleans is 74.8°F. The water main temperature data was approximated using the following formula.[177]

$$T\ of\ water\ main = T_{avg\ ambient} + R \times \Delta T_{amb}$$

Where:

$T_{avg\ ambient}$ = the average annual ambient dry bulb temperature, 68.8°F in New Orleans

R = 0.05

ΔT_{amb} = the average of maximum and minimum ambient air-dry bulb temperature for the month (Tmax + Tmin)/2 where Tmax = maximum ambient dry bulb temperature for the month, and Tmin = minimum ambient dry bulb temperature for the month

Baseline and efficiency-standard water usages per capita were derived from an analysis of metered studies of residential water efficiency retrofit projects conducted for Seattle, WA.; the East Bay Municipal Utility District (CA); and Tampa, FL.[178, 179, 180]

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[177] Burch, J & Christensen, C. 2007. "Towards Development of an Algorithm for Mains Water Temperature." Proceedings of the 2007 ASES Annual Conference, Cleveland, OH.

[178] Seattle Home Water Conservation Study, 2000. "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." December. http://www.allianceforwaterefficiency.org/mainsearch.aspx?searchtext=Seattle%20Home%20Water%20Conservation%20Study

[179] Residential Indoor Water Conservation Study, 2003 "Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area." July. www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=868

180 Tampa Water Department Residential Water Conservation Study, 2004, "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." January 8. https://www.cuwcc.org/Portals/0/Document%20Library/Resources/Water%20Efficient%20Product%20Information/End%20Use%20Studies%20-%20Multiple%20Technologies/Tampa-Residential-Water-Conservation-Final-Report.pdf

C.2.4.7. Estimated Hot Water Usage Reduction

$$Water\ consumption = \frac{\frac{Faucet\ Use\ per\ Person}{Day} \times Occupants\ per\ Home \times \frac{365\ Days}{Year}}{Faucets\ per\ Home}$$

Applying the formula to the values from Table C-50 returns the following baseline and post water consumption.

Baseline (2.2 GPM): 9.7 x 2.37 x 365 / 3.86 = 2,174

Post (1.5 GPM): 8.2 x 2.37 x 365 / 3.86 = 1,838

Post (1.0 GPM): 7.2 x 2.37 x 365 / 3.86 = 1,614

Gallons of water saved per year can be found by subtracting the post consumption in gallons per year per aerator from the baseline consumption.

- Gallons of water saved per year (1.5 GPM): 2,174 – 1,838 = 336
- Gallons of water saved per year (1.0 GPM): 2,174 – 1,614 = 560

Table C-49: Estimated Aerator Hot Water Usage Reduction

Assumption Type	***Seattle Study***[181]	***Tampa Study***[182]	***East Bay Study***	***Average***	***Value used for New Orleans***
Faucet use gallons/person/day (baseline)	9.2	9.4	10.5	9.7	9.7
Faucet use gallons/person/day (1.5 GPM)	8.0	6.2	10.5	8.2	8.2
Faucet use gallons/person/day (1.0 GPM)[183]	--	--	--	--	7.2
Occupants per home	2.54	2.92	2.56	2.67	2.37[184]
Faucets per home[185]	--	--	--	--	3.86
Gal./yr./faucet (baseline)	--	--	--	--	2,174
Gal./yr./faucet (1.5 GPM)	--	--	--	--	1,838
Gal./yr./faucet (1.0 GPM)	--	--	--	--	1,614
Percent hot water	76.10%[4]	Not listed	57.60%5	66.90%	66.9%
Water gallons saved/yr./faucet (1.5 GPM)	--	--	--	--	336
Water gallons saved/yr./faucet (1.0 GPM)	--	--	--	--	560

[181] Average of pre-retrofit percent faucet hot water 72.7% on page 35, and post-retrofit percent faucet hot water 79.5% on page 53.

[182] Average of pre-retrofit percent faucet hot water 65.2% on page 31 and post-retrofit faucet hot water percentage 50.0% on page 54.

[183] This value is a linear extrapolation of gallons per person per day from the baseline (2.2 GPM) and the 1.5 GPM case.

[184] 2010-2014, US Census Bureau. http://www.census.gov/quickfacts/table/PST045215/2255000

[185] Faucets per home assumed to be equal to one plus the number half bathrooms and full bathrooms per home, taken from 2009 RECS, Table HC2.10.

Based on the average percentage hot water shown in Table C-49, the average mixed water temperature across all weather zones was determined. The hot water temperature was found to be 122.695°F in a sample of 144 homes in New Orleans tested by the TPE. The mixed water temperature used in the energy savings calculation can be seen in Table C-50.

Table C-50: Mixed Water Temperature Calculation

Average Water Main Temperature (°F)	***Average Water Heater Setpoint Temperature (°F)***	***Percent Hot Water***	***Mixed Water Temperature (°F)***
74.8	122.695	66.9%	106.8

C.2.4.8. Calculation of Deemed Savings

C.2.4.8.1. Energy Savings

$$Annual\ Energy\ Savings\ = \frac{\rho \times C_P \times V \times (T_{Mixed} - T_{Supply}) \times \left(\frac{1}{RE}\right)}{Conversion\ Factor}$$

Where:

ρ = Water density = 8.33 lb/gal

C_P = Specific heat of water = 1 BTU/lb·°F

V = Gallons of water saved per year per faucet from Table C-50

T_{Mixed} = Mixed water temperature, 106.8°F, from Table C-50

T_{Supply} = Average New Orleans area supply water temperature, 74.8°F

RE = Recovery Efficiency (or in the case of HPWH, EF); if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters, or 0.79 for natural gas water heaters[186].

$Conversion\ Factor$ = 3,412 Btu/kWh for electric water heating or 100,000 Btu/Therm for gas water heating

C.2.4.8.2. Demand Savings

Demand savings for homes with electric water heating were calculated using the following formula:

$$kW_{savings} = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$Ratio_{Annual\ kWh}^{Peak\ kW}$ = 0.000104

[186] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at https://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx

This value is taken from the DOE domestic hot water use study.[187] The DOE domestic hot water use study provided values for the share of daily water use per hour in a profile for shower bath, and sink hot water use. An average was calculated using peak hours of 3 PM to 6 PM to generate an average hourly share of daily water use during peak hours. That value was divided by 365 to generate a ratio of peak share to annual use.

C.2.4.8.3. Example Calculation of Deemed Savings Values

Deemed savings values are per faucet aerator installed.

Table C-51: Example -Replacing 2.2 GPM with 1.5 GPM Faucet Aerator

Faucet Aerator, New Orleans Weather Zone		
Water Usage Reduction (gal)	336	
T_{Supply}	74.8°F	
T_{Mixed}	106.8°F	
Water heater RE (excluding standby losses)	0.98 (Electric) / 2.2 (Heat Pump)	
Energy Savings	Electric: 26.8 kWh	Heat Pump: 11.94 kWh
Demand Savings	Electric: 0.0028 kW	Heat Pump: 0.0012 kW

C.2.4.9. In-Service Rates

Table C-52: In-Service Rates

Delivery Channel	***ISR***
Direct Install	0.98
Mailer Kit[188]	0.45

C.2.4.10. Future Studies

Metering studies for water use are exceedingly expensive. In past metering efforts, the TPE has found costs to exceed $750 per site. As such, we do not advise a metering study for this measure unless savings exceed 5% of residential program savings.

[187] U.S. DOE's 2006. "*Building America Performance Analysis Procedures for Existing Homes*". *National Renewable Energy Laboratory.* May. http://www.nrel.gov/docs/fy06osti/38238.pdf (See Figure 3, page 17.) This TRM looked at hourly share of daily water use at 3pm 4pm, 5pm, and 6pm in Figure 3. The fractions of hourly use derived were 0.022 for 3pm, 0.03 for 4pm, 0.04 for 5pm, and 0.06 for 6pm. The average of these fractions is 0.038, which is the average share of daily water use that falls on a peak hour per day. Dividing that value by 365 days calculates a ratio of 0.000104 as the ratio of peak share to annual use.

[188] Based on primary data collection from 4,572 PY5-9 program participants.

C.2.5. Low-Flow Showerheads

C.2.5.1. Measure Description

This measure consists of removing existing showerheads and installing low-flow showerheads in residences. This measure applies to all residential applications.

C.2.5.2. Baseline and Efficiency Standards

The baseline average flow rate of the existing stock of showerheads is based on the current US DOE standard.

The incentive is for replacement of an existing showerhead with a new showerhead rated at 2.0, 1.75 or 1.5 gallons per minute (GPM). The only showerheads eligible for installation are those that are not easily modified to increase the flow rate.

C.2.5.3. Additional Requirement for Contractor-Installed Showerheads

Existing showerheads that have been defaced so as to make the flow rating illegible are not eligible for replacement. All showerheads removed shall be collected by the contractor and held for possible inspection by the utility until all inspections for invoiced installations have been completed.

Table C-53: Low-Flow Showerhead – Baseline and Efficiency Standards

Measure	***New Showerhead Flow Rate[189] (GPM)***	***Existing Showerhead Baseline Flow Rate (GPM)***
2.0 GPM showerhead	2.00	2.50
1.75 GPM showerhead	1.75	2.50
1.5 GPM showerhead	1.50	2.50

The U.S. Environmental Protection Agency (EPA) WaterSense® Program has implemented efficiency standards for showerheads requiring a maximum flow rate of 2.0 GPM[190].

C.2.5.4. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2014.

[189] All flow rate requirements listed here are the rated flow of the showerhead measured at 80 pounds per square inch of pressure (psi).

[190] https://www.epa.gov/sites/production/files/2018-07/documents/ws-products-specification-showerheads-v1-1.pdf

C.2.5.5. Effect of Weather Zones on Water Usage and Water Main Temperature

Average water main temperature is 74.8°F. The water main temperature data was approximated using the following formula.[191]

$$T\ of\ water\ main = T_{avg\ ambient} + R \times \Delta T_{amb}$$

Where:

R = 0.05

$T_{avg\ ambient}$ = the average annual ambient air dry-bulb temperature

ΔT_{amb} = 74.8 (New Orleans), the average of maximum and minimum ambient air dry-bulb temperature for the month (Tmax + Tmin)/2 where Tmax = maximum ambient dry bulb temperature for the month and Tmin = minimum ambient dry bulb temperature for the month

C.2.5.6. Estimated Hot Water Usage Reduction

Baseline and efficiency standard water usages per capita were derived from an analysis of metered studies of residential water efficiency retrofit projects conducted for Seattle, WA.; the East Bay Municipal Utility District (CA); and Tampa, FL.[192,193,194] See Table C-54 for derivation of water usage values.

To determine water consumption, the following formula was used:

$$\frac{Gallons}{Shower} \times \frac{Showers\ per\ Person}{Day} \times \frac{365\ Days}{Year} \times \frac{Occupants\ per\ Home}{Showerheads\ per\ Home}$$

Applying the formula to the values from Table C-54 returns the following baseline and post water consumption.

- Baseline (2.5 GPM): 20.7 x 0.69 x 365 x 2.37 / 1.62 = 7,627

[191] Burch, J. & Christensen, C. 2007. *"Towards Development of an Algorithm for Mains Water Temperature"* Proceedings of the 2007 ASES Annual Conference, Cleveland, OH.

[192] Seattle Home Water Conservation Study, 2000. "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." December.

http://www.allianceforwaterefficiency.org/mainsearch.aspx?searchtext=Seattle Home Water Conservation Study

[193] Residential Indoor Water Conservation Study, 2003. "Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area." July. http://www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=868

[194] Tampa Water Department Residential Water Conservation Study, 2004, *"The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes,"* January 8. https://www.cuwcc.org/Portals/0/Document%20Library/Resources/Water%20Efficient%20Product%20Information/End%20Use%20Studies%20-%20Multiple%20Technologies/Tampa-Residential-Water-Conservation-Final-Report.pdf

- Post (2.0 GPM): 16.5 x 0.72 x 365 x 2.37 / 1.62 = 6,344
- Post (1.5 GPM): 12.4 x 0.72 x 365 x 2.37 / 1.62 = 4,767

Although the referenced studies do not provide data on 1.75 GPM showerheads, the consumption values for 2.5, 2.0, and 1.5 GPM roughly follow a linear pattern. Taking a simple average of the consumption for 2.0 and 1.5 GPM showerheads returns a value for a 1.75 GPM showerhead:

- Post (1.75 GPM): (6,344 + 4,767) / 2 = 5,556

Gallons of water saved per year can be found by subtracting the post consumption in gallons per year per showerhead from the baseline consumption. These values are also in Table C-54.

- Gallons of water saved per year (2.0 GPM): (7,627 – 6,344) = 1,283
- Gallons of water saved per year (1.75 GPM): (7,627 – 5,556) = 2,071
- Gallons of water saved per year (1.5 GPM): (7,627 – 4,767) = 2,860

Table C-54: Estimated Showerhead Hot Water Usage Reduction

Assumption Type	***Seattle Study[195]***	***Tampa Study***	***East Bay Study[196]***	***Average***	***Value used for New Orleans***
Gallons/shower @ 2.5 GPM (baseline)	19.8	20.0	22.3	20.7	20.7
Gallons/shower @ 2.0 GPM	15.8	16.0	17.8	16.5	16.5
Gallons/shower @ 1.5 GPM	11.9	12.0	13.4	12.4	12.4
Showers/person/day (baseline)	0.51	0.92	0.65	0.69	0.69
Showers/person/day (post)	0.59	0.82	0.74	0.72	0.72
Occupants per home	2.54	2.92	2.56	2.67	2.37[197]
Showerheads per home[198]	not listed	not listed	not listed	not listed	1.62
Water gal./yr./showerhead @ 2.0 GPM saved	not listed	not listed	not listed	not listed	1,283
Water gal./yr./showerhead @ 1.75 GPM saved	not listed	not listed	not listed	not listed	2,071
Water gal./yr./showerhead @ 1.5 GPM saved	not listed	not listed	not listed	not listed	2,860
Percent hot water	74.3%	not listed	66%	70.1%	70.1%

[195] Seattle Study: Average of pre-retrofit percent shower hot water 73.1% on page 35, and post-retrofit percent shower hot water 75.5% on p. 53.

[196] East Bay Study: Average of pre-retrofit percent shower hot water 71.9% on page 31 and post-retrofit shower hot water percentage 60.0% on p. 54.

[197] 2010-2014, US Census Bureau. http://www.census.gov/quickfacts/table/PST045215/2255000

[198] Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2009 RECS, Table HC2.10.

Based on the average percentage hot water shown in, Table C-54, the average mixed water temperature across all weather zones was determined. The hot water temperature was found to be 122.24°F in a sample of 144 homes in New Orleans tested by the TPE. The mixed water temperature used in the energy savings calculation can be seen in Table C-55.

Table C-55: Mixed Water Temperature Calculation

Weather Zone	Average Water Main Temperature (°F)	Average Setpoint Temperature (°F)	Percent Hot Water	Mixed Water Temperature (°F)
New Orleans	74.8	122.695	66.9%	106.8

C.2.5.7. Calculation of Deemed Savings

C.2.5.7.1. Energy Savings

$$Annual\ Energy\ Savings = \frac{\rho \times C_P \times V \times (T_{Mixed} - T_{Supply}) \times \left(\frac{1}{RE}\right)}{Conversion\ Factor}$$

Where:

ρ = Water density = 8.33 lb/gallon

C_P = Specific heat of water = 1 BTU/lb·°F

V = 2.0, 1.75, or 1.5 GPM showerhead water gallons saved per year (from Table C-54)

T_{Mixed} = Mixed water temperature, 106.8°F, from Table C-55

T_{Supply}= Average New Orleans area supply water temperature, 74.8°F

RE = Recovery Efficiency (or in the case of HPWH, EF); if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters,

$Conversion\ Factor$ = 3,412 Btu/kWh for electric water heating or 100,000 Btu/Therm for gas water heating

C.2.5.7.2. Demand Savings

Demand savings were calculated using the US Department of Energy's "Building America Performance Analysis Procedures for Existing Homes"[199] combined domestic hot water use profile which resulted in a ratio of 0.000104 Peak kW to Annual kWh. The DOE domestic hot water use study provided values for the share of daily water use per hour in a profile for shower, bath, and sink hot water use. An average was calculated using peak

[199] U.S. DOE's 2006, *"Building America Performance Analysis Procedures for Existing Homes"*. National Renewable Energy Laboratory. May. www.nrel.gov/docs/fy06osti/38238.pdf

hours of 3pm to 6pm to generate an average hourly share of daily water use during peak hours. That value was divided by 365 to generate a ratio of peak share to annual use.[200]

$$kW_{savings} = kWh_{\ savings} \times Ratio^{Peak\ kW}_{Annual\ kWh}$$

C.2.5.1. Deemed Savings

Table C-56: Low Flow Showerhead Retrofit Deemed Energy Savings

2.0 GPM Showerhead		
Water gal. saved /year/showerhead @ 2.0 GPM	1,283	
T_{Supply}	74.8°F	
T_{Mixed}	106.8°F	
Water heater RE	0.98 (Electric Resistance) / 2.2 (Heat Pump)	
Energy Savings	Electric: 102 kWh	Heat Pump: 46 kWh
Demand Savings	Electric: 0.0106 kW	Heat Pump: 0.0047 kW
1.75 GPM Showerhead		
Water gal. saved /year/showerhead @ 1.5 GPM	2,071	
T_{Supply}	74.8°F	
T_{Mixed}	106.8°F	
Water heater EF (excluding standby losses)	0.98 (Electric Resistance) / 2.2 (Heat Pump)	
Energy Savings	Electric: 165 kWh	Heat Pump: 74 kWh
Demand Savings	Electric: 0.0172 kW	Heat Pump:0.0076 kW
1.5 GPM Showerhead		
Water gal. saved /year/showerhead @ 1.5 GPM	2,860	
T_{Supply}	74.8°F	
T_{Mixed}	106.8°F	
Water heater EF (excluding standby losses)	0.98 (Electric Resistance) / 2.2 (Heat Pump)	
Energy Savings	Electric: 228 kWh	Heat Pump: 102 kWh
Demand Savings	Electric: 0.0237 kW	Heat Pump: 0.0106 kW

C.2.5.1. In-Service Rates

Table C-57: In-Service Rates

Delivery Channel	***ISR***
Direct Install	0.98
Mailer Kit[201]	0.62

[200] At 3pm, the hourly share of daily water use is 0.022, at 4pm is 0.03, at 5pm is 0.04, and at 6pm is 0.06. The average of these values is 0.038. Divided by 365 days, the result is a 0.000104 ratio of peak share to annual use.

[201] Based on primary data collection from 4,572 PY5-9 program participants.

C.2.5.2. Future Studies

The TPE has found costs to exceed $750 per site. As such, we do not advise a metering study for this measure unless savings exceed 5% of residential program savings.

C.2.6. Showerhead Thermostatic Restrictor Valves

C.2.6.1. Measure Description

This measure consists of installing a thermostatic restrictor valve (TRV) between the existing shower arm and showerhead. The valve will reduce behavioral water waste by restricting water flow when the water reaches a set temperature (generally 95˚F). Restricting the flow when the water reaches the temperature set point, reduces the amount of water that goes down the drain prior to the user entering the shower.

C.2.6.2. Baseline and Efficiency Standards

The baseline condition is the residential shower arm and standard (2.5 gpm) showerhead without a thermostatic restrictor valve installed. The baseline average flow rate of the existing stock of showerheads is based on the current US DOE standard.

To qualify for thermostatic restrictor valve deemed savings, the installed equipment must be a thermostatic restrictor valve installed on a residential showerarm and showerhead with either a standard (2.5 gpm) or low-flow (2.0, 1.75, or 1.5 gpm) showerhead. If this measure is installed in conjunction with a low-flow showerhead, refer to C.2.5 Low-Flow Showerheads and claim additional savings as outlined in that measure.

For direct install applications, the residence must have electric resistance water heating.

C.2.6.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2008[202].

C.2.6.4. Effect of Weather Zones on Water Usage and Water Main Temperature

Average water main temperatures for the New Orleans is 74.8°F. The water main temperature data was approximated using the following formula.[203]

$$T\ of\ water\ main = T_{avg\ ambient} + R \times \Delta T_{amb}$$

Where:

$T_{avg\ ambient}$ = the average annual ambient dry bulb temperature, 68.8°F in New Orleans

R = 0.05

ΔT_{amb} = the average of maximum and minimum ambient air-dry bulb temperature for the month (Tmax + Tmin)/2 where Tmax = maximum ambient dry bulb

[202] This value is consistent with the low flow showerhead EUL, DEER 2014.

[203] Burch, J & Christensen, C. 2007. "Towards Development of an Algorithm for Mains Water Temperature." Proceedings of the 2007 ASES Annual Conference, Cleveland, OH.

temperature for the month, and Tmin = minimum ambient dry bulb temperature for the month

C.2.6.5. Estimated Hot Water Usage Reduction

Water usages per capita were derived from an analysis of metered studies of residential water efficiency retrofit projects conducted for Seattle, WA.; the East Bay Municipal Utility District (CA); and Tampa, FL.[204, 205, 206]

Table C-58: Estimated Showerhead Hot Water Usage Reduction

Assumption Type	***Seattle Study***	***Tampa Study***	***East Bay Study***	***Average***	***Value used for New Orleans***
Showers/person/day	0.51	0.92	0.65	0.69	0.69
Occupants per home	2.54	2.92	2.56	2.67	2.37[207]
Showerheads per home[208]	not listed	not listed	not listed	not listed	1.62
Percent hot water	76.1%	Not listed	57.6%	66.9%	66.9%

To determine gallons of behavioral waste (defined as hot water that goes down the drain before the user enters the shower) per year, the following formula was used in conjunction with values from Table C-58.

$$Annual\ Showerhead\ Behavioral\ Waste = SHFR \times BW \times n_S \times 365_{days/year} \times \%_{HW} \times \frac{n_O}{n_{SH}}$$

Where:

$SHFR =$ Showerhead flow rate, gallons per minute (2.5, 2.0, 1.75 and 1.5 gpm)

$BW =$ Behavioral waste, minutes per shower (0.783[209])

$n_S =$ Number of showers per day (0.69)

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204 Seattle Home Water Conservation Study, 2000. "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." December. http://www.allianceforwaterefficiency.org/mainsearch.aspx?searchtext=Seattle%20Home%20Water%20Conservation%20Study Average of pre-retrofit percent shower hot water 73.1% on page 35, and post-retrofit percent shower hot water 75.5% on p. 53.

205 Residential Indoor Water Conservation Study, 2003 "Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area." July. www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=868 Average of pre-retrofit percent shower hot water 71.9% on page 31 and post-retrofit shower hot water percentage 60.0% on p. 54.

206 Tampa Water Department Residential Water Conservation Study, 2004, "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." January 8. https://www.cuwcc.org/Portals/0/Document%20Library/Resources/Water%20Efficient%20Product%20Information/End%20Use%20Studies%20-%20Multiple%20Technologies/Tampa-Residential-Water-Conservation-Final-Report.pdf

207 2010-2014, US Census Bureau. http://www.census.gov/quickfacts/table/PST045215/2255000

208 Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2009 RECS, Table HC2.10.

209 Average behavioral waste from Lutz (2004) Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems and Sherman (2014) Disaggregating Residential Shower Warm-Up Waste. Derived by dividing 47 seconds by 60 seconds.

n_O = Number of occupants per home (2.37)

n_{SH} = Number of showerheads per home (1.62)

$\%_{HW}$ = Percent hot water (.669)

Applying the formula to the values from Table C-58 returns the following values for baseline behavioral waste in gallons per showerhead per year:

2.5 GPM (baseline): 2.5 x 0.783 x 0.69 x 365 x .669 x 2.37/1.62 = 483 *gal*

2.0 GPM: 2.0 x 0.783 x 0.69 x 365 x .669 x 2.37/1.62 = 386 *gal*

1.75 GPM: 1.75 x 0.783 x 0.69 x 365 x .669 x 2.37/1.62 = 338 *gal*

1.5 GPM: 1.5 x 0.783 x 0.69 x 365 x .669 x 2.37/1.62 = 290 *gal*

Table C-59: Gallons of Hot Water Saved per Year

2.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
483	386	338	290

C.2.6.6. Calculation of Deemed Savings

C.2.6.6.1. Energy Savings

$$Annual\ Energy\ Savings = \frac{\rho \times C_P \times V \times (T_{Setpoint} - T_{Supply}) \times \left(\frac{1}{RE}\right)}{Conversion\ Factor}$$

Where:

ρ = Water density = 8.33 lb/gal

C_P = Specific heat of water = 1 BTU/lb·°F

V = Gallons of hot water saved per year (see Table C-59)

$T_{Setpoint}$ = Water heater setpoint temperature (122.695°F[210])

T_{Supply} = Average New Orleans area supply water temperature, 74.8°F

RE = Recovery Efficiency (or in the case of HPWH, EF); if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters[211].

$Conversion\ Factor$ = 3,412 Btu/kWh for electric water heating or 100,000 Btu/Therm for gas water heating

C.2.6.6.2. Demand Savings

Demand savings for homes with electric water heating were calculated using the following formula:

[210] Primary data collections from a sample of 144 homes in New Orleans.

[211] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at https://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx

$$kW_{savings} = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$Ratio_{Annual\ kWh}^{Peak\ kW}$ = 0.000104

C.2.6.7. Deemed Savings

Table C-60 summarizes the deemed kWh and kW for TRVs installed on 2.5, 2.0, 1.75 and 1.5 gpm showerheads, using methods above.

Table C-60. Deemed Savings for TRVs – Showerheads

Showerhead GPM Rating	Water Heater Type	kWh	kW
2.5 gpm	Electric Resistance	58	0.006
	Heat Pump	26	0.003
2.0 gpm	Electric Resistance	46	0.005
	Heat Pump	21	0.002
1.75 gpm	Electric Resistance	40	0.004
	Heat Pump	18	0.002
1.50 gpm	Electric Resistance	35	0.004
	Heat Pump	15	0.002

C.2.6.8. Incremental Cost

The incremental cost of the measure should be the actual program cost (including labor if applicable) or $29.95[212] plus $15.47[11] labor if not available.

C.2.6.9. Future Studies

Metering studies for water use are exceedingly expensive. In past metering efforts, the TPE has found costs to exceed $750 per site. As such, we do not advise a metering study for this measure unless savings exceed 5% of residential program savings.

[212] SCE workpaper SWWH003-01.

C.2.7. Tub Spout Diverters and Thermostatic Restrictor Valves on Showerheads

C.2.7.1. Measure Description

This measure consists of replacing existing tub spouts and shower heads with an automatically diverting tub spout and showerhead system with a thermostatic restrictor valve (TRV) between the existing shower arm and showerhead. When the water temperature reaches a set point (generally 95˚F), the thermostatic restrictor valve will engage the anti-leak diverter. The water will divert from the spout to a showerhead with a closed valve, which prevents the hot water from flowing down the drain prior to use.

C.2.7.2. Baseline and Efficiency Standards

The baseline condition is the residential shower arm and standard (2.5 gpm) showerhead without a thermostatic restrictor valve installed.

To qualify for deemed savings, the installed equipment must be a thermostatic restrictor valve installed on a residential shower arm and showerhead with either a standard (2.5 gpm) or low-flow (2.0, 1.75, or 1.5 gpm) showerhead. If this measure is installed in conjunction with a low-flow showerhead, refer to the Low-Flow Showerheads measure (section C.2.5) and claim additional savings as outlined in that measure.

C.2.7.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2008[213].

C.2.7.4. Effect of Weather Zones on Water Usage and Water Main Temperature

Average water main temperatures for the New Orleans area is 74.8°F. The water main temperature data was approximated using the following formula.[214]

$$T\ of\ water\ main = T_{avg\ ambient} + R \times \Delta T_{amb}$$

Where:

$T_{avg\ ambient}$ = the average annual ambient dry bulb temperature, 68.8°F in New Orleans

R = Decreased efficiency offset (0.05)[208]

ΔT_{amb} = the average of maximum and minimum ambient air-dry bulb temperature for the month (Tmax + Tmin)/2 where Tmax = maximum ambient dry bulb temperature for the month, and Tmin = minimum ambient dry bulb temperature for the month

[213] This value is consistent with the low flow showerhead EUL, DEER 2014.

[214] Burch, J & Christensen, C. 2007. "Towards Development of an Algorithm for Mains Water Temperature." Proceedings of the 2007 ASES Annual Conference, Cleveland, OH.

C.2.7.5. Estimated Hot Water Usage Reduction

Water usages per capita were derived from an analysis of metered studies of residential water efficiency retrofit projects conducted for Seattle, WA.; the East Bay Municipal Utility District (CA); and Tampa, FL.[215, 216, 217]

Table C-61: Estimated Showerhead Hot Water Usage Reduction

Assumption Type	Seattle Study	Tampa Study	East Bay Study	Average	Value used for New Orleans
Showers/person/day	0.51	0.92	0.65	0.69	0.69
Occupants per home	2.54	2.92	2.56	2.67	2.37[218]
Showerheads per home[219]	not listed	not listed	not listed	not listed	1.62
Percent hot water	76.1%	Not listed	57.6%	66.9%	66.9%

This system provides savings in two parts: elimination of behavioral waste (hot water that goes down the drain prior to the user entering the shower) and elimination of tub spout diverter leakage. Total gallons of water saved are the sum of these two parts.

Part 1: To determine gallons of behavioral waste (defined as hot water that goes down the drain before the user enters the shower) per year, the following formula was used in conjunction with values from Table C-61.

$$Annual\ Showerhead\ Behavioral\ Waste = \%WUE_{SH} \times SHFR \times BW \times n_S \times 365_{days/year} \times \%_{HW} \times \frac{n_O}{n_{SH}}$$

$$Annual\ Tub\ Spout\ Behavioral\ Waste = \%WUE_{TS} \times TSFR \times BW \times n_S \times 365_{days/year} \times \%_{HW} \times \frac{n_O}{n_{SH}}$$

Where:

$\%WUE_{SH}$ = Showerhead percentage of warm-up events (0.6[220])

[215] Seattle Home Water Conservation Study, 2000. "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." December. http://www.allianceforwaterefficiency.org/mainsearch.aspx?searchtext=Seattle%20Home%20Water%20Conservation%20Study Average of pre-retrofit percent shower hot water 73.1% on page 35, and post-retrofit percent shower hot water 75.5% on p. 53.

[216] Residential Indoor Water Conservation Study, 2003 "Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area." July. www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=868 Average of pre-retrofit percent shower hot water 71.9% on page 31 and post-retrofit shower hot water percentage 60.0% on p. 54.

[217] Tampa Water Department Residential Water Conservation Study, 2004, "The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes." January 8. https://www.cuwcc.org/Portals/0/Document%20Library/Resources/Water%20Efficient%20Product%20Information/End%20Use%20Studies%20-%20Multiple%20Technologies/Tampa-Residential-Water-Conservation-Final-Report.pdf

[218] 2010-2014, US Census Bureau. http://www.census.gov/quickfacts/table/PST045215/2255000

[219] Showerheads per home assumed to be equal to the number of full bathrooms per home, taken from 2009 RECS, Table HC2.10.

[220] Percent of warm up events from (Sherman 2014) Disaggregating Residential Shower Warm-Up Waste

$\%WUE_{TS}$ = Showerhead percentage of warm-up events (0.4[8])

$SHFR =$ Showerhead flow rate, gallons per minute (2.5, 2.0, 1.75 and 1.5 gpm)

$TSFR =$ Tub Spout flow rate, gallons per minute (4 gpm)

$BW =$ Behavioral waste, minutes per shower (0.783[221])

$n_S =$ Number of showers per day (0.69)

$n_O =$ Number of occupants per home (2.37)

$n_{SH} =$ Number of showerheads per home (1.62)

$\%_{HW} =$ Percent hot water (.669)

Applying the formula to the values used for New Orleans from returns the following values for baseline behavioral waste in gallons per showerhead and tube spout per year:

Showerheads:

$$2.5 \text{ GPM (baseline)}: 0.6 \text{ x } 2.5 \text{ x } 0.783 \text{ x } 0.69 \text{ x } 365 \text{ x } .669 \text{ x } 2.37/1.62 = 290\ gal$$

$$2.0 \text{ GPM}: 0.6 \text{ x } 2.0 \text{ x } 0.783 \text{ x } 0.69 \text{ x } 365 \text{ x } .669 \text{ x } 2.37/1.62 = 232\ gal$$

$$1.75 \text{ GPM}: 0.6 \text{ x } 1.75 \text{ x } 0.783 \text{ x } 0.69 \text{ x } 365 \text{ x } .669 \text{ x } 2.37/1.62 = 203\ gal$$

$$1.5 \text{ GPM}: 0.6 \text{ x } 1.5 \text{ x } 0.783 \text{ x } 0.69 \text{ x } 365 \text{ x } .669 \text{ x } 2.37/1.62 = 174\ gal$$

Tub Spout:

$$5.0 \text{ GPM}: 0.4 \text{ x } 5.0 \text{ x } 0.783 \text{ x } 0.69 \text{ x } 365 \text{ x } .669 \text{ x } 2.37/1.62 = 386\ gal$$

Table C-62: Water Savings by Flow Rate (gallons)

2.5 gpm	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**Tub Spout**
290	232	203	174	386

Part 2: To determine the baseline gallons of diverted leakage per year, the following formula was used:

$$Annual\ Diverter\ Waste = DLR \times t_S \times n_S \times 365_{days/year} \times \%_{HW} \times \frac{n_O}{n_{SH}}$$

Where:

$DLR =$ Showerhead percentage of warm-up events

(Appendix B, Question 8).

221 Average behavioral waste from Lutz (2004) Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems and Sherman (2014) Disaggregating Residential Shower Warm-Up Waste. Derived by dividing 47 seconds by 60 seconds.

t_s = Shower time (mins/shower) (5.68[222])

n_S = Number of showers per day (0.69)

n_O = Number of occupants per home (2.37)

n_{SH} = Number of showerheads per home (1.62)

$\%_{HW}$ = Diverter water percentage (.669)

Applying the formula to the values used for New Orleans from Table C-61 returns the following values:

Diverter (0.8 gpm): 0.8 x 5.68 x 0.69 x 365 x 2.37/1.62 x .737= 1,270 *gal*

Total water saved: To determine gallons of water saved per year can be found by adding the total waste from previous calculations:

$$Gallons\ Hot\ Water\ Saved = SHBW + TSBW + DW$$

Where:

$SHBW$ = Showerhead behavioral waste (see Table C-62) (gal)

$TSBW$ = Tub spout behavioral waste (386 gal)

DW = Diverter waste (1,270 gal)

C.2.7.6. Calculation of Deemed Savings

C.2.7.6.1. Energy Savings

$$Annual\ Energy\ Savings = \frac{\rho \times C_P \times V \times (T_{Setpoint} - T_{Supply}) \times \left(\frac{1}{RE}\right)}{Conversion\ Factor}$$

Where:

ρ = Water density = 8.33 lb/gal

C_P = Specific heat of water = 1 BTU/lb·°F

V = Total gallons of water saved per year (see steps 1 and 2)

$T_{Setpoint}$ = Water heater setpoint temperature (122.695°F[223])

T_{Supply} = Average New Orleans area supply water temperature, 74.8°F

RE = Recovery Efficiency (or in the case of HPWH, EF); if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters[224].

[222] RTF Workpaper: "Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV (2015)" https://rtf.nwcouncil.org/sites/default/files/proposed_measures/Calculating%20Tub%20Spout%20Savings%2018Dec15.pdf

[223] Primary data collections from a sample of 144 homes in New Orleans.

[224] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at https://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx

$Conversion\ Factor =$ 3,412 Btu/kWh for electric water heating

C.2.7.6.2. Demand Savings

Demand savings for homes with electric water heating were calculated using the following formula:

$$kW_{savings} = kWh_{savings} \times Ratio^{Peak\ kW}_{Annual\ kWh}$$

Where:

$Ratio^{Peak\ kW}_{Annual\ kWh}$ = 0.000104

C.2.7.7. Deemed Savings

Table C-63 summarizes the deemed kWh and kW for TRVs installed on 2.5, 2.0, 1.75 and 1.5 gpm showerheads, using methods above.

Table C-63. Deemed Savings for TRVs – Showerheads

Showerhead GPM Rating	Water Heater Type	kWh	kW
2.5 gpm	Electric Resistance	232	0.024
	Heat Pump	103	0.011
2.0 gpm	Electric Resistance	225	0.023
	Heat Pump	100	0.010
1.75 gpm	Electric Resistance	222	0.023
	Heat Pump	99	0.010
1.50 gpm	Electric Resistance	218	0.023
	Heat Pump	97	0.010

C.2.7.8. Incremental Cost

The incremental cost of the measure should be the actual program cost (including labor if applicable) or $91.38[225] plus $20[226] labor if not available.

C.2.7.9. Future Studies

Metering studies for water use are exceedingly expensive. In past metering efforts, the TPE has found costs to exceed $750 per site. As such, we do not advise a metering study for this measure unless savings exceed 5% of residential program savings.

[225] SCE workpaper SWWH001-Rev00.

[226] Estimate for contractor installation time.

C.3. HVAC

C.3.1. Central Air Conditioner Replacement

C.3.1.1. Measure Description

This measure involves a residential retrofit with a new central air conditioning system or the installation of a new central air conditioning system in a residential new construction (packaged unit, or split system consisting of an indoor unit with a matching remote condensing unit). Maximum cooling capacity per unit is 65,000 BTU/hour. This measure applies to all residential applications.

C.3.1.2. Baseline and Efficiency Standards[227]

For new construction (NC) and ROB projects, the cooling baseline is 14 SEER, consistent with the current federal minimum standard[228].

For Early Replacement projects, the baseline is consistent with the previous federal standard. The cooling baseline is 13 SEER (code which took effect January 23, 2006).

For Early Replacement, the maximum lifetime age of an eligible piece of equipment is capped at the point at which it is expected that 75 percent of the equipment has failed. Where the age of the unit exceeds the 75 percent failure age, ROB savings should be applied. This cap prevents early retirement savings from being applied to projects where the age of the equipment greatly exceeds the estimated useful life of the measure.

Air conditioning equipment shall be properly sized to the dwelling, based on ASHRAE or ACCA Manual J standards. Manufacturer data sheets on installed air conditioning equipment or the AHRI reference number must be provided to the utility. The installed central air conditioning equipment must be AHRI certified.

Table C-64: Central Air Conditioner – Baseline and Efficiency Levels

	SEER	***EER***
New Construction and Normal Replacement	14	11.8
Early Replacement	13	11.2
Required Efficiency	15	12.5 (split) 12.0 (packaged)

[228] DOE minimum efficiency standard for residential air conditioners/heat pumps. www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75.

C.3.1.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 19 years, according to the US DOE.[229]

C.3.1.1. Deemed Savings

Table C-65: High Efficiency Central AC Deemed kWh

Efficiency	***kWh Saved per Ton***	***Average Tons[230]***	***kWh if Tonnage Unknown***
15 SEER	93.54	3.65	341.43
16 SEER	175.39	3.65	640.18
17 SEER	247.61	3.65	903.79
18 SEER	311.81	3.65	1,138.10
19 SEER	369.25	3.65	1,347.76
20 SEER	420.94	3.65	1,536.44
21 SEER	467.71	3.65	1,707.16

Table C-66: High Efficiency Central AC Deemed kW

Efficiency	***kW Saved per Ton***	***Average Tons[231]***	***kW if Tonnage Unknown***
12 EER	0.0131	3.65	0.0476
13 EER	0.0723	3.65	0.2638
14 EER	0.1231	3.65	0.4491
15 EER	0.1671	3.65	0.6097
16 EER	0.2056	3.65	0.7503
17 EER	0.2395	3.65	0.8743
18 EER	0.2697	3.65	0.9845

C.3.1.2. Deemed Savings Calculations

C.3.1.2.1. Replace-on-Burnout

$$kWh_{Savings} = CAP_c \times \frac{1}{1{,}000} W/_{kW} \times \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{Eff}}\right) \times EFLH_C$$

$$kW_{Savings} = CAP_c \times \frac{1}{1{,}000} W/_{kW} \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{Eff}}\right) \times \%CF$$

Where,

[229] U.S. DOE, 2011 Technical Support Document: "Residential Central Air Conditioners, Heat Pumps, and Furnaces, 8.2.3.5 Lifetime." June www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75.

[230] Value from PY6 Residential Heating & Cooling Program

[231] Value from PY6 Residential Heating & Cooling Program

CAP_c = Cooling capacity (in BTU)

EER_{base} = Full-load efficiency of baseline equipment (see Table C-64)

EER_{eff} = Full-load efficiency of baseline equipment (see Table C-64)

$SEER_{base}$ = Seasonal efficiency of baseline equipment (see Table C-64)

$SEER_{eff}$ = Seasonal efficiency of efficient equipment (see Table C-64)

$EFLH_c$ = Equivalent Full-Load Cooling Hours

%CF = Peak Coincidence Factor

C.3.1.2.2. Equivalent Full-Load Hours

Equivalent Full-Load Cooling Hours (EFLHc) measures the total annual runtime of HVAC equipment. To support development of this value, the usage of 68 HVAC systems in New Orleans was metered. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans.

The resulting EFLHc is 1,637.

C.3.1.2.3. Peak Coincidence Factor

The Peak Coincidence Factor is defined as the percent time during the ENO peak period where the residential central air conditioner is operational. Peak hours were defined as:

- Weekdays
- Non-holidays
- 4:00-5:00 PM
- Average ambient temperature exceeding 90 degrees Fahrenheit.

The average central AC runtime during qualified hours was 77%. This peak coincidence factor is applied to calculate peak kW demand reductions from this measure.

C.3.1.2.4. Uncertainty Analysis

The uncertainties associated with the two key parameters collected in EM&V are as follows:

- EFLHc: ±7.81%
- % Coincidence: ±2.11%

C.3.1.3. Incremental Cost

The incremental cost of high central air conditioners is detailed in Table C-67.[232]

Table C-67: High Efficiency Central AC Replacement Incremental Costs

Product Type	Incremental Cost Per Ton
15 SEER	$119
16 SEER	$238
17 SEER	$357
18 SEER	$477
19 SEER	$596
20 SEER	$715
21 SEER	$789

C.3.1.4. Future Studies

This measure should be considered for supplementary data collection pertaining to runtime and peak coincidence in three years (PY9, program year 2019-2020).

[232] CA DEER 2014

C.3.2. Window Air Conditioner Replacement

C.3.2.1. Measure Description

This measure involves the replacement of a window air conditioner in a residential building.

C.3.2.2. Baseline and Efficiency Standards[233]

The baseline is a new air conditioning unit with a combined energy efficiency ratio (CEER) that meets federal standards established on June 1, 2014[234].

Efficient units must meet ENERGY STAR standards, requiring 10% efficiency above federal minimum requirements.

Table C-68: Window Air Conditioner – Baseline and Efficiency Levels

Reverse Cycle?	***Louvered Sides?***	***Capacity***	***Baseline CEER***	***Efficient CEER***	***kWh***	***kW***
No	Yes	< 8,000	11.0	12.1	46.4	0.0445
		≥ 8,000 and < 14,000	10.9	12.0	74.2	0.0453
		≥ 14,000 and < 20,000	10.7	11.8	118.8	0.0470
		≥ 20,000	9.4	10.3	171.5	0.0501
	No	< 8,000	10.0	11.0	51.0	0.0490
		≥ 8,000	9.6	10.6	78.8	0.0530
Yes	Yes	< 20,000	9.8	10.8	113.7	0.0509
		≥ 20,000	9.3	10.2	190.3	0.0511
	No	< 14,000	9.3	10.2	83.7	0.0511
		≥ 14,000	8.7	9.6	146.9	0.0581

C.3.2.3. Estimated Useful Life (EUL)

According to the DOE's Technical Support Document, Chapter 8: Life Cycle Cost and Payback Period Analyses 2011, the measure life is 10.5 years.

C.3.2.4. Deemed Savings Calculations

C.3.2.4.1. Replace-on-Burnout

$$kWh_{Savings} = CAP_c \times \frac{1}{1{,}000} {}^{W}\!/_{kW} \times \left(\frac{1}{CEER_{base}} - \frac{1}{CEER_{Eff}}\right) \times EFLH_C \times RAF$$

$$kW_{Savings} = CAP_c \times \frac{1}{1{,}000} {}^{W}\!/_{kW} \times \left(\frac{1}{CEER_{base}} - \frac{1}{CEER_{Eff}}\right) \times \%CF$$

[234] 10 CFR 430.32(b). https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=52&action=viewlive#current_standards

Where,

CAP_c = Cooling capacity (in BTU)

$CEER_{base}$ = Full-load efficiency of baseline equipment (see Table C-68)

$CEER_{eff}$ = Full-load efficiency of baseline equipment (see Table C-68)

$CEER_{base}$ = Seasonal efficiency of baseline equipment (see Table C-68)

$CEER_{eff}$ = Seasonal efficiency of efficient equipment (see Table C-68)

EFLHc = Equivalent Full-Load Cooling Hours, 1,637

%CF = Peak Coincidence Factor, 77%

RAF = Room AC Adjustment Factor, .49[235]

C.3.2.4.2. Equivalent Full-Load Hours

Equivalent Full-Load Cooling Hours (EFLHc) measures the total annual runtime of HVAC equipment. To support development of this value, the usage of 68 HVAC systems in New Orleans was metered. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans.

The resulting EFLHc is 1,637.

C.3.2.4.3. Peak Coincidence Factor

The Peak Coincidence Factor is defined as the percent time during the ENO peak period where the residential central air conditioner is operational. Peak hours were defined as:

- Weekdays
- Non-holidays
- 4:00-5:00 PM
- Average ambient temperature exceeding 90 degrees Fahrenheit.

The average central AC runtime during qualified hours was 77%. This peak coincidence factor is applied to calculate peak kW demand reductions from this measure.

C.3.2.4.4. Uncertainty Analysis

The uncertainties associated with the two key parameters collected in EM&V are as follows:

- EFLHc: ±7.81%
- % Coincidence: ±2.11%

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235 This is a factor derived from the ENERGY STAR calculator which corrects for the fact that window AC's are typically not run as often as central AC systems. This value comes from the Arkansas TRM, which developed estimates based on the ENERGY STAR Room AC calculator.

C.3.2.5. Incremental Cost

The incremental cost of high central air conditioners is $50[236].

C.3.2.1. Net-to-Gross Ratio

The NTGR for this measure is 62%[237].

C.3.2.2. Future Studies

This measure should be considered for supplementary data collection pertaining to runtime and peak coincidence in three years (PY9, program year 2019-2020).

[236] ENERGY STAR Room AC Calculator.

[237] Based on primary data collection from 30 PY6-9 program participants.

C.3.3. Electronically Commutated Motors on Furnace Fans

C.3.3.1. Measure Description

Electronically Commutated Motors (ECMs) are motors that provide the power to furnace blowers to circulate the heated air required for space conditioning. This measure focuses on ECMs installed on residential furnace fans and is not applicable for ECMs on separate air handling units. ECMs operate using a built-in inverter and magnetic rotor to vary the torque and/or air flow rate required by the HVAC system. These motors are able to maintain their high efficiency at a variety of operation points thus improving their desirability compared to baseline motors.

C.3.3.2. Baseline and Efficiency Standards

The baseline equipment for this measure is different depending on if the measure is retrofit or new construction. Two types of baseline equipment exist; Shaded-pole (SP) motors and permanent split capacitor (PSC) motors on residential furnaces.

C.3.3.2.1. Retrofit (Early Replacement)

The baseline equipment for retrofit is the existing motor type.

C.3.3.2.2. New Construction (Includes Major Remodel & ROB)

The baseline equipment for new construction is a PSC motor.

C.3.3.3. Deemed Savings Calculations

The algorithms below are to be used to calculate electric energy and demand reductions for this measure:

$$kWh_{savings} = \left(\frac{hp_{base}}{Eff_{base}} - \frac{hp_{ECM}}{Eff_{ECM}}\right) \times 0.746 \times EFLH_h \times y$$

$$kW_{savings} = \left(\frac{hp_{base}}{Eff_{base}} - \frac{hp_{ECM}}{Eff_{ECM}}\right) \times 0.746 \times CF$$

Where,

hp_{base} = Rated horsepower of baseline motor, hp

hp_{ECM} = Rated horsepower of installed ECM, hp

Eff_{pre} = Efficiency of baseline motor as found in the table below, %

Eff_{ECM} = Efficiency of ECM as found in the table below, %

$EFLH_h$ = Equivalent full load hours of heating, 1,118

Y = Ratio of fan motor on to burner on as calculated below,

CF = Coincidence Factor, 0.71

The ratio of blower on time to furnace burner on time can be taken as 1.39 based on DOE estimated values or calculated based on the DOE furnace test procedure shown below[238] if the relevant parameters are known.

$$y = \frac{t^{+} - t^{-}}{t_{ON}}$$

Where,

t^{+} = off-period between burner shutdown and blower shutdown (blower off delay), min

t^{-} = on-period between burner shutdown and blower shutdown (blower off delay), min

t_{ON} = average burner on-time, min

C.3.3.4. Calculation Variables

Typical motor efficiency values were obtained for HVAC applications from a DOE report[239] and can be found below. The original report provided a range; however, the median value of the range was extracted for use in calculating savings.

Table C-69: Furnace Fan Efficiency Values

Motor Type	Efficiency (%)
Shaded-Pole	30
Permanent Split Capacitor	60
Electronically Commutated	75

C.3.3.5. Estimated Useful Life (EUL)

The EUL of this measure was taken from the Arkansas TRM 6.0, page 379. The given value is 15 years and was originally obtained from DEER 2008.

C.3.3.6. Incremental Cost

Actual material and labor costs should be used when available. When not available, the incremental cost of this measure should be $475[240].

[238] U.S. Department of Energy (2014, June). TECHNICAL SUPPORT DOCUMENT: ENERGY EFFICIENCY PROGRAM FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT: RESIDENTIAL FURNACE FANS.

[239] W. G., T. S., & C. R. (2013, December 4). Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment. Retrieved August 21, 2018, from https://www.energy.gov/sites/prod/files/2014/02/f8/Motor Energy Savings Potential Report 2013-12-4.pdf

[240] https://www.nrel.gov/docs/fy14osti/60760.pdf

C.3.3.7. Future Studies

There will be a convenient sample to meter for these fans when direct load control is metered. The TPE recommends conducting furnace baseline metering alongside DLC metering to validate the baseline for this measure.

Measure performance could receive metering if this measure constitutes more than 1% of portfolio savings.

C.3.4. Heat Pump Replacement

C.3.4.1. Measure Description

This measure involves a residential retrofit with a new heat pump system or the installation of a new heat pump system in a residential new construction (packaged unit, or split system consisting of an indoor unit with a matching remote condensing unit). Maximum cooling capacity per unit is 65,000 BTU/hour. This measure applies to all residential applications.

C.3.4.2. Baseline and Efficiency Standards[241]

For new construction (NC) and ROB projects, the cooling baseline is 14 SEER and 8.0 HSPF, consistent with the current federal minimum standard[242].

For Early Replacement projects, the baseline is consistent with the previous federal standard. The cooling baseline is 13 SEER (code which took effect January 23, 2006).

For Early Replacement, the maximum lifetime age of an eligible piece of equipment is capped at the point at which it is expected that 75 percent of the equipment has failed. Where the age of the unit exceeds the 75 percent failure age, ROB savings should be applied. This cap prevents early retirement savings from being applied to projects where the age of the equipment greatly exceeds the estimated useful life of the measure.

Heat Pump equipment shall be properly sized to the dwelling, based on ASHRAE or ACCA Manual J standards. Manufacturer data sheets on installed air conditioning equipment or the AHRI reference number must be provided to the utility. The installed central air conditioning equipment must be AHRI certified.

Table C-70: Heat Pump – Baseline and Efficiency Levels

	SEER	***EER***	***HSPF***
Required	15	12.5 (split) 12.0 (packaged)	9
New Construction and Normal Replacement	14	11.8	8.2 (split) 8.0 (packaged)
Early Retirement - Heat Pump	13	11.2	7.7 (split & packaged)
New Construction and Normal Replacement (Replacing Electric Resistance with Heat Pump)	14	11.8	3.41
Early Retirement - Electric Resistance to Heat Pump (Replacing Electric Resistance with Heat Pump)	13	11.2	3.41

242 DOE minimum efficiency standard for residential air conditioners/heat pumps. www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75.

C.3.4.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 16 years, according to the US DOE.[243]

C.3.4.4. Deemed Savings Values

The values in Table C-71 through Table C-74 reflect the per-ton and per-unit averages from the PY5 through to-date PY9 program years and should be used when nameplate data cannot be collected.

C.3.4.4.1. Cooling kWh and kW Savings

Table C-71: Deemed Cooling kWh Savings

Efficiency	***kWh Saved per Ton***	***Average Tons[244]***	***kWh if Tonnage Unknown***
15 SEER	93.54	3.01	281.26
16 SEER	175.39	3.01	527.36
17 SEER	247.61	3.01	744.51
18 SEER	311.81	3.01	937.53
19 SEER	369.25	3.01	1,110.23
20 SEER	420.94	3.01	1,265.66
21 SEER	467.71	3.01	1,406.29

Table C-72: Deemed Cooling kW Savings

Efficiency	***kW Saved per Ton***	***Average Tons[4]***	***kW if Tonnage Unknown***
12 EER	0.044	3.01	0.132
13 EER	0.083	3.01	0.248
14 EER	0.116	3.01	0.350
15 EER	0.147	3.01	0.441
16 EER	0.174	3.01	0.522
17 EER	0.198	3.01	0.595
18 EER	0.220	3.01	0.661

[243] US U.S. DOE, 2011. *Technical Support Document: "Residential Central Air Conditioners, Heat Pumps, and Furnaces, 8.2.3.5 Lifetime*". June. www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75.

[244] Average reduction based on PY5-PY9 tracking data for 8,160 dwellings.

C.3.4.4.2. Heating kWh Savings

Table C-73: Deemed Heating kWh Savings – ROB/NC (Heat Pump Baseline)

Efficiency	kWh Saved per Ton	Average Tons[245]	kWh if Tonnage Unknown
9 HSPF	66.00	3.01	198.44
10 HSPF	118.80	3.01	357.20
11 HSPF	162.00	3.01	487.09
12 HSPF	198.00	3.01	595.33
13 HSPF	228.46	3.01	686.92
14 HSPF	254.57	3.01	765.43
15 HSPF	277.20	3.01	833.46

Table C-74: Heating kWh Savings- ROB/NC (Electric Resistance Baseline)

Efficiency	kWh Saved per Ton	Average Tons[5]	kWh if Tonnage Unknown
9 HSPF	865.55	3.01	2,602.47
10 HSPF	918.35	3.01	2,761.22
11 HSPF	961.55	3.01	2,891.11
12 HSPF	997.55	3.01	2,999.35
13 HSPF	1028.01	3.01	3,090.94
14 HSPF	1054.12	3.01	3,169.45
15 HSPF	1076.75	3.01	3,237.49

C.3.4.5. Calculation of Deemed Savings

C.3.4.5.1. Replace-on-Burnout

C.3.4.5.1.1. Cooling Savings

$$kW_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{Eff}}\right) \times \%CF$$

$$kWh_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{Eff}}\right) \times EFLH_C$$

Where,

CAP_c = Cooling capacity (in BTU)

EER_{base} = Full-load efficiency of baseline equipment (see Table C-70)

[245] Average reduction based on PY5-PY9 tracking data for 8,160 dwellings.

EER_{eff} = Full-load efficiency of baseline equipment (see Table C-70)

$SEER_{base}$ = Seasonal efficiency of baseline equipment (see Table C-70)

$SEER_{eff}$ = Seasonal efficiency of efficient equipment (see Table C-70)

EFLHc = Equivalent Full-Load Cooling Hours

%CF = Peak Coincidence Factor

C.3.4.5.1.2. Heating Energy Savings

Heating savings are calculated with the following formula:

$$kWh_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{Eff}}\right) \times EFLH_h$$

Where,

CAP_c = Cooling capacity (in BTU)

EER_{base} = Full-load efficiency of baseline equipment (see Table C-70)

EER_{eff} = Full-load efficiency of baseline equipment (see Table C-70)

$HSPF_{base}$ = Heating Season Performance Factor of baseline equipment (see Table C-70)

$HSPF_{eff}$ = Heating Season Performance Factor of efficient equipment (see Table C-70)

$EFLH_h$ = Equivalent Full-Load Heating Hours, 600

%CF = Peak Coincidence Factor

C.3.4.5.2. Derivation of Equivalent Full-Load Hours and Peak Coincidence Factor

C.3.4.5.2.1. Cooling Hours

Equivalent Full-Load Cooling Hours (EFLHc) measures the total annual runtime of HVAC equipment. To support development of this value, the usage of 68 HVAC systems in New Orleans was metered over the course of three years. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans.

The resulting EFLHc is 1,37.

C.3.4.5.2.2. Peak Coincidence Factor

The Peak Coincidence Factor is defined as the percent time during the ENO peak period where the residential central air conditioner is operational. Peak hours were defined as:

- Weekdays
- Non-holidays
- 4:00-5:00 PM
- Average ambient temperature exceeding 90 degrees Fahrenheit.

The average central AC runtime during qualified hours was 77%. This peak coincidence factor is applied to calculate peak kW demand reductions from this measure.

C.3.4.5.2.3. Heating Hours

Equivalent Full-Load Heating Hours ($EFLH_h$) measures the total annual runtime of heating equipment. To support development of this value, the usage of 295 electric heating systems in New Orleans was estimated using a billing analysis. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans. In addition, the $EFLH_h$ was multiplied by a scaling factor of 1.51 to account for differences in usage for heat pump vs. electric resistance heating types.

The heat pump scaling factor was calculated using the following equation:

$$Scaling\ Factor_{HP} = ((\frac{\frac{kWh}{HDD}}{Ton}_{HP}) * COP_{HP}) / ((\frac{\frac{kWh}{HDD}}{Ton}_{ER}) * COP_{ER})$$

Where,

$kWh/HDD/Ton_{HP}$= Weighted average of predicted kWh/HDD/Ton for heat pump heating types for single and multi-family homes = 0.3282

$kWh/HDD/Ton_{ER}$= Weighted average of predicted kWh/HDD/Ton for electric resistance heating types for single and multi-family homes = 0.4348

COP_{HP} = Coefficient of performance for heat pumps = 2.0

COP_{HP} = Coefficient of performance for electric resistance = 1.0

The resulting $EFLH_H$ for Electric Resistance systems 396.

The resulting $EFLH_H$ for Heat Pumps is 600.

C.3.4.5.2.4. Uncertainty Analysis

The uncertainties associated with the four key parameters collected in EM&V are as follows:

- EFLHc: ±5.10%
- % Coincidence: ±2.11%
- EFLHh: Electric Resistance ±5.10%
- EFLHh: Heat Pumps ±37.10%

C.3.4.6. Incremental Cost

The incremental cost of high efficiency heat pump is detailed in Table C-75[246].

Table C-75: Replacement Incremental Costs (HP Baseline)

Efficiency	Incremental Cost Per Ton
15 SEER	$303
16 SEER	$438
17 SEER	$724
18 SEER	$724

The incremental costs of retiring an electric resistance heating system early and replacing it with a high efficiency heat pump are detailed in the table below.

Table C-76: Replacement Incremental Costs (ER Baseline)

Efficiency	Incremental Cost Per Ton[247]
15 SEER	$1,724
16 SEER	$1,859
17 SEER	$2,145
18 SEER	$2,145

C.3.4.7. Future Studies

As with Central Air Conditioning, the cooling side of this measure should be considered for supplementary data collection pertaining to runtime and peak coincidence in three years (PY9, program year 2019-2020).

[246] CA DEER 2014

[247] Average RUL is 6 years according to DEER. Remaining years are discounted using the Entergy New Orleans Utility Discount Rate.

C.3.5. Ground Source Heat Pump Replacement

C.3.5.1. Measure Description

This measure involves the installation of water-to-air ground source heat pump as a replacement for an existing air-source heat pump. Maximum cooling capacity per unit is 65,000 BTU/hour. This measure applies to all residential applications.

C.3.5.2. Baseline and Efficiency Standards[248]

For new construction (NC) and ROB projects, the cooling baseline is 14 SEER and 8.0 HSPF, consistent with the current federal minimum standard[249]. Due to the high cost of this equipment, all projects are assumed to be replacement on burnout or new construction.

Heat Pump equipment shall be properly sized to the dwelling, based on ASHRAE or ACCA Manual J standards. Manufacturer data sheets on installed air conditioning equipment or the AHRI reference number must be provided to the utility. The installed central air conditioning equipment must be AHRI certified.

Table C-77: Heat Pump – Baseline and Efficiency Levels

	SEER	EER	HSPF
New Construction and Normal Replacement	14	11.8	8.2 (split)
			8.0 (packaged)
Early Replacement – Heat Pump	13	11.2	7.7 (split & packaged)
Early Replacement – Electric Resistance	13	11.2	3.41
Energy Star Criteria – Water-to-Air		Closed Loop: 17.1	Closed Loop: 12.3
		Open Loop: 21.1	Open Loop: 14.0
Energy Star Criteria – Water-to-Water		Closed Loop: 16.1	Closed Loop: 10.6
		Open Loop: 20.1	Open Loop: 11.9
		DGX: 16	DGX: 12.3

C.3.5.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 25 years, according to the US DOE.[250]

[249] DOE minimum efficiency standard for residential air conditioners/heat pumps. www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75.

[250] Source DOE Energy Savers website: www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640 .

C.3.5.4. Deemed Savings Values

Savings are calculated in the same manner as for Heat Pump Replacement. See Section C.3.4.5. According to the current ENERGY STAR database[251], the average efficiency of ENERGY STAR-rated ductless units that are currently in production is as follows:

- COP: 4.30 (this converts to a SEER rating of 20.86 and HSPF of 14.67)
- EER: 24.60

The resulting average unit energy savings for a geothermal heat pump are detailed in the table below.

Table C-78: Geothermal Heat Pump Deemed Savings

	kWh Per Ton	kW per Ton	Average Tons[252]	kWh per Unit	kW per Unit
New Construction and Normal Replacement	849	0.4074	3.01	2,552	1.23
Early Replacement – Heat Pump	1,014	0.4494	3.01	3,048	1.35
Early Replacement – Electric Resistance	2,190	0.4494	3.01	6,585	1.35

C.3.5.5. Incremental Cost

New Construction and Time of Sale: The actual installed cost of the Ground Source Heat Pump should be used (default of $3957 per ton[253]), minus the assumed installation cost of the baseline equipment ($1381 per ton for ASHP[254] or $2011 for a new baseline 80% AFUE furnace or $3543 for a new 82% AFUE boiler[255] and $952 per ton[256] for new baseline Central AC replacement).

Early Replacement: The full installation cost of the Ground Source Heat Pump should be used (default provided above). The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $1,518 per ton for a new

[251] https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Most-Efficient-Geothermal-Heat-Pumps/4c82-7ysy

[252] Average reduction based on program tracking data for 8,160 dwellings.

[253] Based on data provided in 'Results of Home geothermal and air source heat pump rebate incentives documented by IL electric cooperatives.

[254] Baseline cost per ton derived from DEER 2008 Database Technology and Measure Cost Data. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.

[255] Furnace and boiler costs are based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor.

[256] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator.

baseline Air Source Heat Pump, or $2,903 for a new baseline 90% AFUE furnace or $4,045 for a new 82% AFUE boiler and 1,047 per ton for new baseline Central AC replacement[257]. This future cost should be discounted to present value using the nominal societal discount rate.

C.3.5.6. Future Data Collection Needs

As with Central Air Conditioning, the cooling side of this measure should be considered for supplementary data collection pertaining to runtime and peak coincidence in three years (PY9, program year 2019-2020).

[257] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.91%.

C.3.6. Ductless Heat Pump

C.3.6.1. Measure Description

This measure involves the installation of ductless mini-split heat pumps (DMSHP). These systems have increased savings over efficient air source heat pumps as they use less fan energy to move heat and cooled air and don't incur distribution losses.

C.3.6.2. Baseline and Efficiency Standards

For new construction (NC) and ROB projects, the cooling baseline is 14 SEER and 8.0 HSPF, consistent with the current federal minimum standard[258]. Due to the high cost of this equipment, all projects are assumed to be replacement on burnout or new construction.

A DMSHP must be a high-efficiency, variable-capacity system that exceeds program minimum efficiency requirements. Qualified systems will typically have an inverter-driven DC motor.

Heat Pump equipment shall be properly sized to the dwelling, based on ASHRAE or ACCA Manual J standards. Manufacturer data sheets on installed air conditioning equipment or the AHRI reference number must be provided to the utility. The installed central air conditioning equipment must be AHRI certified.

Table C-79: Heat Pump – Baseline and Efficiency Levels

	SEER	***EER***	***HSPF***
New Construction and Normal Replacement	14	11.8	8.2 (split)
			8.0 (packaged)
Early Replacement – Heat Pump	13	11.2	7.7 (split & packaged)

C.3.6.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 18 years.[259]

C.3.6.4. Deemed Savings Values

Savings are calculated in the same manner as for Heat Pump Replacement. See Section C.3.4.5. According to the current AHRI database[260], the average efficiency of ENERGY STAR-rated ductless units that are currently in production is as follows:

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[258] DOE minimum efficiency standard for residential air conditioners/heat pumps. www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75.

[259] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007

[260] https://www.ahridirectory.org/ahridirectory/pages/vsmshp/cee/defaultSearch.aspx

- SEER: 21.17
- EER: 12.79
- HSPF: 10.43

The average capacity of these units is 2.28 tons.

The resulting average unit energy savings for a ductless mini-split are detailed in the table below. This is per-unit installed in a residence; a retrofit may constitute installation of multiple units, and if so, the calculation is performed separately for each and the savings added.

Table C-80: Ductless Mini-Split Average Savings

	kWh Per Ton	kW per Ton	Average Tons	kWh per Unit	kW per Unit
New Construction and Normal Replacement	599	0.0606	3.01	1,801	0.18
Early Replacement – Heat Pump	745	0.1026	3.01	2,239	0.31

C.3.6.5. Incremental Cost

New Construction and Time of Sale: The actual installed cost of the DMSHP should be used (defaults are provided below), minus the assumed installation cost of the baseline equipment ($1,381 per ton for ASHP[261] or $2,011 for a new baseline 80% AFUE furnace or $3,543 for a new 82% AFUE boiler[262] and $952 per ton[263] for new baseline Central AC replacement).

Default full cost of the DMSHP is provided below. Note, for smaller units a minimum cost of $2,000 should be applied[264]:

Table C-81: Ductless Mini-Split Full Installed Cost

Unit Size	Full Install Cost ($/ton)[265]
9-9.9	$1,443
10-10.9	$1,605

[261] Baseline cost per ton derived from DEER 2008 Database Technology and Measure Cost Data. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.

[262] Furnace and boiler costs are based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor. Where efficiency ratings are not provided, the values are interpolated from those that are.

[263] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator

[264] The cost per ton table provides reasonable estimates for installation costs of DMSHP, which can vary significantly due to requirements of the home. It is estimated that all units, even those 1 ton or less will be at least $2000 to install.

[265] Full costs based upon full install cost of an ASHP plus incremental costs provided in Memo from Opinion Dynamics Evaluation Team, Ductless Mini-Split Heat Pumps: Incremental Cost Analysis, April 27, 2017.

11-12.9	$1,715
13+	$2,041

The incremental cost of the DSMHP compared to a baseline minimum efficiency DSMHP is provided in the table below[266].

Table C-82: Ductless Mini-Split Incremental Cost

Efficiency (HSPF)	***Incremental Cost ($/ton) over an HSPF 8.0 DHP***
9-9.9	$62
10-10.9	$224
11-12.9	$334
13+	$660

Early Replacement/retrofit (replacing existing equipment): The full installation cost of the DMSHP should be used (default provided above). The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $1,518 per ton for a new baseline Air Source Heat Pump, or $2,903 for a new baseline 90% AFUE furnace or $4,045 for a new 82% AFUE boiler and $1,047 per ton for new baseline Central AC replacement[267]. If replacing electric resistance heat, there is no deferred replacement cost. This future cost should be discounted to present value using the nominal societal discount rate.

Where the DMSHP is a supplemental HVAC system, the full installation cost of the DMSHP should be used (default provided above) without a deferred replacement cost.

C.3.6.6. Future Data Collection Needs

As with Central Air Conditioning, the cooling side of this measure should be considered for supplementary data collection pertaining to runtime and peak coincidence in three years (PY9, program year 2019-2020).

The baseline for ductless systems may vary widely. Program implementers and the TPE should coordinate to ensure collection of baseline data for these projects.

[266] Memo from Opinion Dynamics Evaluation Team, Ductless Mini-Split Heat Pumps: Incremental Cost Analysis, April 27, 2017

[267] All baseline replacement costs are consistent with their respective measures and include inflation rate of 1.91%.

C.3.7. Central Air Conditioner and Heat Pump Tune-Up

C.3.7.1. Measure Description

This measure applies to central air conditioners and heat pumps. An AC tune-up, in general terms, involves checking, adjusting and resetting the equipment to factory conditions, such that it operates closer to the performance level of a new unit. This measure applies to all residential applications.

For this measure, the service technician must complete the following tasks according to industry best practices:

- Air Conditioner Inspection and Tune-Up Checklist[268]
- Inspect and clean condenser, evaporator coils, and blower.
- Inspect refrigerant level and adjust to manufacturer specifications.
- Measure the static pressure across the cooling coil to verify adequate system airflow and adjust to manufacturer specifications.
- Inspect, clean, or change air filters.
- Calibrate thermostat on/off set points based on building occupancy.
- Tighten all electrical connections, and measure voltage and current on motors.
- Lubricate all moving parts, including motor and fan bearings.
- Inspect and clean the condensate drain.
- Inspect controls of the system to ensure proper and safe operation. Check the starting cycle of the equipment to assure the system starts, operates, and shuts off properly.
- Provide documentation showing completion of the above checklist to the utility or the utility's representative.

C.3.7.2. Baseline and Efficiency Standards

The baseline is a system with demonstrated imbalances of refrigerant charge.

After the tune-up, the equipment must meet airflow and refrigerant charge requirements. To ensure the greatest savings when conducting tune-up services, the eligibility minimum requirement for airflow is the manufacturer specified design flow rate, or 350 CFM/ton, if unknown. Also, the refrigerant charge must be within +/- 3 degrees of target sub-cooling for units with thermal expansion valves (TXV) and +/- 5 degrees of target super heat for units with fixed orifices or a capillary.

[268] Based on ENERGY STAR® HVAC Maintenance Checklist. www.energystar.gov/index.cfm?c=heat_cool.pr_maintenance

The efficiency standard, or efficiency after the tune-up, is assumed to be the manufacturer specified energy efficiency ratio (EER) of the existing central air conditioner or heat pump. The efficiency improvement resulting from the refrigerant charge adjustment depends on the pre-adjustment refrigerant charge.

C.3.7.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to CA DEER 2014.

C.3.7.4. Deemed Savings Values

The methodologies in this chapter detail the approach program staff should take to capture data needed to calculate savings from AC tune-ups. However, this data may not always be readily available or measurable. The values in Table C-83 and Table C-84 reflect the per-ton and per-unit averages from the PY5 through to-date PY9 program years and should be used when test data cannot be collected. HSPF and EER gains used in deemed calculations were derived from the same data.

Table C-83: AC Tune-Up Deemed Savings Single Family Dwelling

System Type	kWh/Ton	kW/Ton	Average Tons[269]	kWh	kW
Central AC	283.27	0.1332	3.28	929	0.437
Central HP	603.17	0.1332	3.28	1,978	0.437

Table C-84: AC Tune-Up Deemed Savings Multifamily Dwelling

System Type	kWh/Ton	kW/Ton	Average Tons[270]	kWh	kW
Central AC	283.27	0.1332	2.46	697	0.328
Central HP	603.17	0.1332	2.46	1,484	0.328

C.3.7.5. Deemed Savings Calculations

There are two ways in which deemed savings can be calculated for this measure:

1) Test-in and test-out efficiency; or
2) Application of a stipulated reduction in annual use.

C.3.7.5.1. Test-in and Test-out Efficiency

$$kWh_{Savings\_Cooling} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times EFLH_C$$

[269] Average cooling capacity of 7,393 units servicing single family dwellings

[270] Average cooling capacity 767 units servicing multifamily dwellings

$$kWh_{Savings\_Heating} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right) \times EFLH_H$$

$$kW_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \%CF$$

Where,

CAP_c = Cooling capacity (in BTU)

EER_{pre} = Efficiency of the equipment prior to tune-up

EER_{post}= Nameplate efficiency of the existing equipment

EFLHc = Equivalent Full-Load Cooling Hours = 1,637

EFLHh = Equivalent Full-Load Heating Hours = 600

$HSPF_{pre}$ = Measured efficiency of the heating equipment before tune-up

$HSPF_{post}$ = Measured efficiency of the heating equipment after tune-up

%CF = Peak Coincidence Factor

$$kWh_{Central\ AC} = kWh_{Savings\_Cooling}$$

$$kWh_{Heat\ Pumps} = kWh_{Savings\_Cooling} + kWh_{Savings\_Heating}$$

C.3.7.5.2. Baseline Efficiency

Baseline efficiency is calculated as:

$$EER_{pre} = (1 - EL) \times EER_{post}$$

EL is the Efficiency Loss based on the current refrigerant charge level. The EL values are summarized in Table C-85 and Table C-86.

Table C-85: Efficiency Loss by Refrigerant Charge Level (Fixed Orifice)

% Charged	EL
≤70	.37
75	.29
80	.20
85	.15
90	.10
95	.05
100	0
≥120	.03

Table C-86: Efficiency Loss by Refrigerant Charge Level (TXV)

% Charged	EL
≤70	.12
75	.09

80	.07
85	.06
90	.05
95	.03
100	.00
≥120	.04

C.3.7.5.3. Equivalent Full-Load Hours

Equivalent Full-Load Cooling Hours (EFLHc) measures the total annual runtime of HVAC equipment. To support development of this value, the usage of 68 HVAC systems in New Orleans was metered. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans.

The resulting EFLHc is 1,637.

Equivalent Full-Load Heating Hours ($EFLH_h$) measures the total annual runtime of heating equipment. To support development of this value, the usage of 295 electric heating systems in New Orleans was estimated using a billing analysis. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans. In addition, the $EFLH_h$ was multiplied by a scaling factor of 1.51 to account for differences in usage for heat pump vs. electric resistance heating types.

The heat pump scaling factor was calculated using the following equation:

$$Scaling\ Factor_{HP} = ((\frac{\frac{kWh}{HDD}}{Ton}_{HP}) * COP_{HP})/((\frac{\frac{kWh}{HDD}}{Ton}_{ER}) * COP_{ER})$$

Where,

$kWh/HDD/Ton_{HP}$= Weighted average of predicted kWh/HDD/Ton for heat pump heating types for single and multi-family homes = 0.3282

$kWh/HDD/Ton_{ER}$= Weighted average of predicted kWh/HDD/Ton for electric resistance heating types for single and multi-family homes = 0.4348

COP_{HP} = Coefficient of performance for heat pumps = 2.0

COP_{HP} = Coefficient of performance for electric resistance = 1.0

C.3.7.5.4. Peak Coincidence Factor

The Peak Coincidence Factor is defined as the percent time during the ENO peak period where the residential central air conditioner is operational. Peak hours were defined as:

- Weekdays
- Non-holidays
- 4:00-5:00 PM

- Average ambient temperature exceeding 90 degrees Fahrenheit.

The average central AC runtime during qualified hours was 77%. This peak coincidence factor is applied to calculate peak kW demand reductions from this measure.

C.3.7.5.5. % Off Annual Use

Alternatively, program administrators may elect to claim savings based off of a percent reduction in annual use.

$$kWh_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{EER_{pre}}\right) \times EFLH_C \times \%Reduction$$

$$kWh_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{EER_{pre}}\right) \times EFLH_C \times \%Reduction$$

$$kW_{Savings} = CAP_c \times 1kW/1{,}000W \times \left(\frac{1}{EER_{pre}}\right) \times \%CF\%Reduction$$

In this, EERpre is assumed to be 10.164[271]. Percent reduction is 17.2%. This value is derived with PY7 through PY9 Residential Heating & Cooling Program data.

$$kWh_{Central\ AC} = kWh_{Savings\_Cooling}$$

$$kWh_{Heat\ Pumps} = kWh_{Savings\_Cooling} + kWh_{Savings\_Heating}$$

C.3.7.5.6. Uncertainty Analysis

The uncertainties associated with the two key parameters collected in EM&V are as follows:

- EFLHc: ±7.81%
- EFLHh: Heat Pumps ±37.10%
- % Coincidence: ±2.11%

C.3.7.6. Incremental cost

The incremental cost of an AC Tune-Up is $175[272].

C.3.7.7. Net-to-Gross Ratio

The NTGR for this measure is 82%[273].

C.3.7.8. Future Studies

The incremental cost value is very sensitive to labor costs, and as such a New Orleans-specific cost study should be conducted to revise this value.

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[271] Averaged measured EER from 1,564 pre tune-up tests.

[272] Illinois TRM 7.0

[273] Based on primary data collection from 135 PY6-9 program participants.

C.3.8. Duct Sealing

C.3.8.1. Measure Description

This measure is comprised of performing duct sealing using mastic sealant or metal tape to the distribution system of homes with a central air conditioning system. Materials should be long-lasting materials such as UL 181A or UL 181 B-approved foil tape. Fabric-based duct tape is not allowed.

In calculating savings for this measure, program administrators are to use the leakage-to-unconditioned space metric, entailing a blower-door subtraction test method. this technique is described in detail on p.44 of the Energy Conservatory Blower Door Manual; which can be found on the Energy Conservatory website[274].

C.3.8.2. Baseline and Efficiency Standards

The baseline for this measure is unsealed ductwork, with a maximum pre-installation leakage rate of 40% of total fan flow[275]. This cap is imposed because interior temperature in homes that exceed 40 percent total leakage would be above the thermally acceptable comfort levels published by ASHRAE in its 2009 Fundamentals publication. Historically, homeowners would remedy a situation in such a state of disrepair, and out of concern for the validity of baseline test measurements performed by duct sealing contractors and to ensure that the savings are program attributable, program administrators must cap baseline leakage at 40% of fan flow, and report the extent to which contractors' baseline leakage measurements exceed this fan flow.

C.3.8.3. Estimated Useful Life (EUL)

According to DEER 2014, the Estimated Useful Life for duct sealing is 18 years.

C.3.8.4. Deemed Savings Values

The methodologies in this chapter detail the approach program staff should take to capture data needed to calculate savings from duct sealing. However, this data may not always be readily available or measurable. The average leakage values in Table C-87 and Table C-88 reflect the average per-home leakage reductions from 5,163 residential single and multifamily duct sealing projects, spanning PY5 though PY9 with correction factors resulting from on-site testing applied[276]. Additional deemed inputs which have been created from program data averages and used in savings calculations are detailed in section C.3.8.5 below.

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[274] As of Oct 2014: http://www.energyconservatory.com/sites/default/files/documents/mod_3-4_dg700_-_new_flow_rings_-_cr_-_tpt_-_no_fr_switch_manual_ce_0.pdf

[275] Total Fan Flow = Cooling Capacity (tons) × 400

[276] PY5 to PY9 average

Table C-87: Duct Sealing Deemed Savings Values – Single Family

System Type	Average Leakage Reduction[277]	kWh	kW
AC with Gas Heat	471	2,465	1.159
Heat Pump	471	2,879	1.159
AC with Electric Resistance Heat	471	4,106	1.159
Electric Resistance Heat, no AC	471	1,641	0.000

Table C-88: Duct Sealing Deemed Savings Values – Multifamily

System Type	Average Leakage Reduction[278]	kWh	kW
AC with Gas Heat	443	2,317	1.090
Heat Pump	443	2,707	1.090
AC with Electric Resistance Heat	443	3,860	1.090
Electric Resistance Heat, no AC	443	1,543	0.000

C.3.8.5. Deemed Savings Calculations

The following formulas shall be used to calculate deemed savings for duct sealing.

C.3.8.5.1. Cooling Savings

$$kWh_{cooling} = \frac{\left(DL_{pre} - DL_{post}\right) \times EFLH_c \times (h_{out}\rho_{out-}h_{in}\rho_{in}) \times 60}{1000 \times SEER}$$

Where,

DL_{pre} = Pre-measurement of leakage to unconditioned space

DL_{post} = Post-measurement of leakage to unconditioned space

$EFLH_c$ = Equivalent Full Load Cooling Hours, 1,637, based on the TPE's metering of New Orleans homes

[277] Based on average results from 4,939 SF participants over PY5-9.

[278] Based on average results from 325 MF participants over PY5-9.

H_{out} = Outdoor design enthalpy, 40 BTU/lb.

H_{in} = Indoor design enthalpy, 30 BTU/lb.

P_{out} = Density of outdoor air at 95 deg. F, .0740 lb./ft.^{3}

P_{in} = Density of outdoor air at 95 deg. F, .0756 lb./ft.^{3}

SEER = Seasonal Efficiency Rating of existing systems (BTU/W*hr.). Default of 13

1,000 = W/kW conversion factor

60 = Minutes/hour conversion factor

The default of 13 SEER is based on the inspection of 182 program participants in Home Performance with ENERGY STAR and Assisted Home Performance with ENRGY STAR. These 182 participants had 135 unique model numbers, with an average SEER of 12.98. The minimum code prior to 2015 was 13 SEER and given how close the mean value is to that code value, we recommend a default SEER of 13.

C.3.8.5.2. Heating Savings (Heat Pump)

Heating savings are calculated as:

$$kWh_{Heating,Heat\ Pump} = \frac{(DL_{pre} - DL_{post})/((CAP/12{,}000) * 400) * EFLH_h * CAP * TRFheat}{\eta\text{Heat} \ / \ 3{,}412}$$

Where,

DL_{pre} = Pre-measurement of leakage to unconditioned space

DL_{post} = Post-measurement of leakage to unconditioned space

CAP = Heating output capacity (Btuh) of electric heat = Actual. Use 72,829[279] Btu/hr if CAP unavailable.

12,000 = Btu/ton conversion factor

400 = CFM/ton conversion factor

$EFLH_h$ = Equivalent full load heating hours of heat pumps = 600[280]

TRF_{heat} = Thermal Regain Factor for heating by space type = 1.0 for Unconditioned Spaces = 0.40 for Semi-Conditioned Spaces

ηHeat = Efficiency in COP of Heating equipment = Actual. If unavailable, use 2.40.

3,412 = Conversion of BTU/kWh.

[279] Average heating capacity of 2,022 program participants.

[280] Measured metering data from 295 New Orleans residences.

The default CAP of 72,829 is based on average capacity found for 2,022 residential customers who participated in a residential program PY5-PY9.

C.3.8.5.3. *Heating Savings (Electric Resistance)*

Heating savings are calculated as:

$$kWh_{Heating,Electric\ Resistance} = \frac{(DL_{pre} - DL_{post})/((CAP/12{,}000) * 400) * EFLH_h * CAP * TRFheat}{\eta\text{Heat} / 3{,}412}$$

Where,

DL_{pre} = Pre-measurement of leakage to unconditioned space

DL_{post} = Post-measurement of leakage to unconditioned space

CAP = Heating output capacity (Btu/hr) of electric heat = Actual. Use 72,829[281] Btu/hr if CAP unavailable.

12,000 = Btu/ton conversion factor

400 = CFM/ton conversion factor

$EFLH_h$ = Equivalent full load heating hours = 396[282]

TRF_{heat} = Thermal Regain Factor for heating by space type = 1.0 for Unconditioned Spaces = 0.40 for Semi-Conditioned Spaces

ηHeat = Efficiency in COP of Heating equipment = Actual. If unavailable, use 1.0.

3,412 = Conversion of BTU/kWh.

C.3.8.5.4. *Demand Savings (Cooling)*

Demand savings are calculated by applying peak coincidence to the Cooling kWh savings. If the residence does not have central air conditioning (i.e., the ductwork is used only for heating distribution) then demand savings are 0.

$$kW = \frac{kWh_{cooling}}{EFLH_c} \times Coincidence\%$$

Where,

$kWh_{cooling}$ = Calculated kWh cooling savings

$EFLH_c$ = Equivalent Full Load Cooling Hours, 1,637, based on the TPE 's metering of New Orleans homes

[281] Average heating capacity of 2,022 program participants.

[282] Measured metering data from 295 New Orleans residences.

Coincidence% = 77%, calculated based on the TPE's metering of New Orleans homes.

C.3.8.5.5. Derivation of Equivalent Full-Load Hours and Peak Coincidence Factor

C.3.8.5.5.1. Cooling Hours

Equivalent Full-Load Cooling Hours (EFLHc) measures the total annual runtime of HVAC equipment. To support development of this value, the usage of 68 HVAC systems in New Orleans was metered over. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans.

The resulting EFLHc is 1,637.

C.3.8.5.5.2. Peak Coincidence Factor

The Peak Coincidence Factor is defined as the percent time during the ENO peak period where the residential central air conditioner is operational. Peak hours were defined as:

- Weekdays
- Non-holidays
- 4:00-5:00 PM
- Average ambient temperature exceeding 90 degrees Fahrenheit.

The average central AC runtime during qualified hours was 77%. This peak coincidence factor is applied to calculate peak kW demand reductions from this measure.

C.3.8.5.5.3. Heating Hours

Equivalent Full-Load Heating Hours ($EFLH_h$) measures the total annual runtime of heating equipment. To support development of this value, the usage of 295 electric heating systems in New Orleans was estimated using a billing analysis. This runtime was then normalized to correspond to Typical Meteorological Year ("TMY") weather data for New Orleans. In addition, the $EFLH_h$ was multiplied by a scaling factor of 1.51 to account for differences in usage for heat pump vs. electric resistance heating types.

The heat pump scaling factor was calculated using the following equation:

$$Scaling\ Factor_{HP} = \left(\left(\frac{\frac{kWh}{HDD}}{Ton}_{HP}\right) * COP_{HP}\right) / \left(\left(\frac{\frac{kWh}{HDD}}{Ton}_{ER}\right) * COP_{ER}\right)$$

Where,

$kWh/HDD/Ton_{HP}$= Weighted average of predicted kWh/HDD/Ton for heat pump heating types for single and multi-family homes = 0.3282

$kWh/HDD/Ton_{ER}$= Weighted average of predicted kWh/HDD/Ton for electric resistance heating types for single and multi-family homes = 0.4348

COP_{HP} = Coefficient of performance for heat pumps = 2.0

COP_{HP} = Coefficient of performance for electric resistance = 1.0

The resulting $EFLH_H$ for Electric Resistance systems 396.

The resulting $EFLH_H$ for Heat Pumps is 600.

C.3.8.5.5.4. Uncertainty Analysis

The uncertainties associated with the four key parameters collected in EM&V are as follows:

- EFLHc: ±5.10%
- % Coincidence: ±2.11%
- EFLHh: Electric Resistance ±5.10%
- EFLHh: Heat Pumps ±37.10%

C.3.8.6. Incremental cost

The incremental cost of this measure is the full installed cost. If this is not available than the PY6 average cost of $368 may be used instead.

C.3.8.7. Net-to-Gross Ratio

The NTGR for this measure is 95%[283].

C.3.8.8. Future Studies

This is a high impact measure, regularly constituting a large percent of Energy Smart program savings. The TPE recommends that savings estimates for Duct Sealing be validated with a billing analysis of the past three years of program participants.

[283] Based on primary data collection from 282 PY6-9 program participants.

C.3.9. Smart Thermostats

C.3.9.1. Measure Description

The Smart Thermostats measure involves the replacement of a manually operated or programmable thermostat with a smart programmable thermostat. This measure applies to all residential applications.

Recent research[284] indicates that today's programmable thermostat is evolving into a more usable, capable, and connected device. Smart thermostats are the next generation of programmable thermostats, which provide an array of features including automatic occupancy sensing and set-point adjustment. An energy management system that includes a communicating climate control will provide energy users with vastly improved and potentially real-time information on heating, ventilation, and air conditioning (HVAC) consumption and cost. Armed with these capabilities, consumers are able to take immediate action to reduce energy use and see the results in real-time.

The location of the smart thermostat can affect its performance and efficiency. To operate properly, a thermostat must be installed on an interior wall away from direct sunlight, drafts, doorways, skylights, and windows.[285] Additionally, thermostats should be installed in a location with the house that is regularly occupied while residents are home.

For homes with a heat pump, smart thermostats must be professionally installed and commissioned. Smart thermostats on heat pumps must be capable of controlling heat pumps to optimize energy use and minimize the use of backup electric resistance heat.

Smart thermostats have capabilities beyond those found in a traditional programmable thermostat. To qualify as a smart thermostat, the units installed, at a minimum, should have the following capabilities and installation parameters:

- 1. Successful connection to existing WIFI
- 2. Remote adjustment via smart phone or online
- 3. Automatic scheduling
- 4. Energy history
- 5. Occupancy sensing (set "on" as a default)

Other optional features include:

- 1. Early on function to allow desired set points to be met at onset of occupancy
- 2. Filter reminders
- 3. On screen indication when temperature is set to an energy saving value

[284] Archived ENERGY STAR® Programmable Thermostat Specification. www.energystar.gov/index.cfm?c=archives.thermostats_spec.

[285] U.S. DOE, "Thermostats." May 7, 2015. http://energy.gov/energysaver/articles/thermostats.

- 4. For heat pumps, smart thermostat must be able to control heat pump to optimize energy use and minimize the use of backup electric resistance heat

C.3.9.2. Baseline and Efficiency Standards

The baseline condition is a manually operated or properly programmed thermostat.

C.3.9.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life for thermostats is 11 years.[286]

C.3.9.4. Deemed Savings Values

The deemed savings values for this measure is 343 kWh per household.

Savings are based on the results of the Smart Thermostat Direct Install Pilot Program, comprised of 894 multifamily dwellings, with 749 used in the estimation of final savings.

Billing data was used from program participants and supplemented with a matched control group. The evaluation used a pre-post fixed effects model with a vector of control variables for each month to capture seasonal effects. This is called a model specification allows the model to capture much of the baseline differences across customers while obtaining reliable estimates of the impact of the thermostat installation. The reductions are calculated in terms of kWh per day.

The model is shown below in Equation 1:

Equation 1: P Pre-Post Fixed Effects Model

$$kWh\ Usage_{it} = \alpha_0 + \beta_1 * Post_i + \beta_2 * Post_i * Treatment_i$$
$$+ \beta_3 * Month_t + \beta_4 * Post_i * Month_t + \beta_5 * Post_i * Treatment_i * Month_t$$
$$+ \beta_6 * Customer_i + \varepsilon_{it}$$

Where

i = *i*th customer

t = the first, second, third, etc. month of the post-treatment period

$kWh\ Usage_{it}$ = the average daily use during month *t* for household *i* in the post-treatment period

$Post_i$ = a dummy indicator for whether an observation for household *i* occurs pre- or post-installation of the thermostat

$Treatment_i$ = a dummy indicator for whether the household was a participant household with a Nest thermostat installed

$Month_t$ = the month of the billing period *t*

$Post_i * Treatment_i$ = an interaction term between the Post and Treatment variables

[286] Database for Energy Efficient Resources (2014). www.deeresources.com/.

$Post_i * Month_t$ = an interaction term between the Post and Month variables

$Post_i * Treatment_i * Month_t$ = an interaction term between the Post, Treatment and Month variables

$Customer_i$ = a customer-specific dummy variable which account for exogenous heterogeneity that cannot be explicitly controlled for (for a Fixed Effects Model)

α_0 = an intercept term

ε_{it} = an error term

In this specification, the predicted participant savings in the post-period are calculated as in Equation 2.

Equation 2: Participant Annual Savings

$$Participant\ Annual\ Savings = \sum_{t=1}^{12\ months} \left\{ \beta_{2t} * \frac{Days}{Month_t} + \beta_{5t} * \frac{Days}{Month_t} \right\}$$

Where,

β_2 = the coefficient for Post*Treatment parameter

β_5 = the coefficient for the Post*Treatment*Month parameter, which captures the seasonal factors following the installation of the thermostat

$\frac{Days}{Month_t}$ = the total number of days during billing period t

Below, Table C-89 shows the model results and average annual savings per household.

Table C-89: Model Results and Annual Savings

	Average Annual Usage (kWh)	Average Annual kWh Savings	kWh Savings (%)	Average kWh Savings Variance	Error[287]	90% Confidence Interval	R^2
Annual Average	12,821.58	343.13	2.68%	3,300.19	94.50	(248.63, 437.63)	0.6797

C.3.9.5. Incremental Cost

For HPwES and other programs for which installation services are provided, the actual material, labor, and other costs should be used. If this is not available, use $394.17 for retrofit, $199.12 for new construction.[288]

[287] Square root of Monthly kWh Savings Variance, multiplied by 1.645 (z-score at 90% confidence).

[288] Measure and base equipment costs are taken from Pacific Gas & Electric Workpaper SW13XX### https://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/57d7624aebbd1a24f2855382/1473733196367/Workpaper+CA+Residential+Smart+Thermostat+Statewide+WorkPaper+Draft+2.pdf. Measure and base labor

C.3.9.6. Future Studies

This sample from the program pilot was sufficient to provide statistically valid savings on a per-dwelling basis, but not sufficient to provide robust savings based on annual household energy use. In PY8 Smart Thermostat installations through residential programs is sufficient to perform a supplementary billing analysis of the measure. This analysis should be used to update this TRM chapter, basing saving on annual household energy use.

costs are taken from Northeast Energy Efficiency Partnerships 'Emerging Technologies Incremental Cost Study Final Report' http://www.neep.org/file/4475/download?token=ALT2qBvt Table 3-22.

C.4. Envelope Measures

C.4.1. Attic Knee Wall Insulation

C.4.1.1. Measure Description

This measure involves adding attic knee wall insulation to un-insulated knee wall areas in residential dwellings of existing construction. A wall with an insulation value of R-0 has no insulation but does have a nominal wall R-value made up of interior and exterior wall materials, air film and wood studs. This measure applies to all residential applications.

C.4.1.2. Baseline and Efficiency Standards

This measure applies to existing construction only.

Table C-90: Attic Knee Wall Insulation – Baseline and Efficiency Standards

Baseline	***Efficiency Standard***
Uninsulated knee wall	Minimum R-19 or R-30

C.4.1.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 20 years, based on NEAT v. 8.6.

C.4.1.4. Deemed Savings

This measure has not been included in Energy Smart programs to-date. To provide an estimate of per-project savings, we use PY6 average project size for attic insulation. The average project in PY6 Home Performance with Energy Star was 1,633 square feet. For this estimation, we assume a square attic (40.41 feet per wall side). The assumed knee-wall height is three feet. The resulting surface area to be insulated is:

$$Knee - Wall\ Area = 40.41_{Wall\ length} \times 4_{\#walls} \times 3_{Wall\ height} = 496.92\ ft.^2$$

Table C-91: Knee Wall Insulation – Deemed Savings Values Per Residence

Ceiling Insulation Base R-Value	**AC/Gas Heat kWh**	**AC/Electric Resistance kWh**	**Heat Pump kWh**	**AC Peak Savings (kW)**
	(/ sq. ft.)	**(/ sq. ft.)**	**(/ sq. ft.)**	**(/ sq. ft.)**
R-19	1,789	487	3,328	1,155
R-30	2,225	302	3,747	1,297

Table C-92: Knee Wall Insulation – Deemed Savings Values Per Square Foot

Ceiling Insulation Base R-Value	AC/Gas Heat kWh	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings (kW)
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
R-19	3.600	6.698	2.324	0.000
R-30	4.477	7.540	2.610	0.000

C.4.1.5. Calculation of Deemed Savings

The deemed savings are dependent on the R-value of the attic knee wall, pre- and post-retrofit.

BEopt™ was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since attic knee wall insulation savings are sensitive to weather, available TMY3 weather data specific to each of the four Arkansas weather regions was used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

C.4.1.6. Incremental Cost

The incremental cost for this measure is the total cost. The cost is $0.035 per sq. ft. per "R" unit of insulation[289]. For the average project size of 496.92 square feet, the resulting cost is:

- R-19: $330
- R-49: $522

C.4.1.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values based on simulation results. If this measure is added to Energy Smart programs and exceeds 1% of residential savings, then the simulation model should be updated to align with the billed use of customers that install the measure.

[289] Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

C.4.2. Ceiling Insulation

C.4.2.1. Measure Description

This measure requires adding ceiling insulation above a conditioned area in a residential dwelling of existing construction to a minimum ceiling insulation value of R-30. Savings are also estimated for an optional final insulation level of R-38 and R-49. This measure applies to all residential applications.

This measure pertains to ceiling insulation only (attic floor). There is a separate measure (Measure 2.2.5) for roof deck insulation.

C.4.2.2. Baseline and Efficiency Standards

In existing construction, ceiling insulation levels vary greatly, depending on the age of the home, type of insulation, and attic space utilization (such as using the attic for storage and HVAC equipment). The average pre-retrofit insulation level of the treated area will be determined and documented by the insulation contractor according to the ranges in Table C-93. Degradation due to age and condition of the existing insulation will need to be considered by the insulation contractor. Care must be exercised in differentiating between an existing R-value in the 0-1 range versus in the 2-4 range as the resulting savings are very sensitive in the lower ranges.

The eligibility standard for this measure (minimum final R-value) is R-30, as specified in IECC 2009. Savings are also provided for R-38 and R-49 as an optional final R-value, as specified for IECC climate zone 4 beginning in IECC 2012.

Table C-93: Ceiling Insulation – Baseline and Efficiency Standards

Baseline	***Efficiency Standard***
R-0 to R-1	R-30, R-38 or R-49
R-2 to R-4	
R-5 to R-8	
R-9 to R-14	
R-15 to R-22	

C.4.2.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 20 years, according to DEER 2014.

C.4.2.4. Deemed Savings Values

Deemed savings values have been calculated for four HVAC configurations: AC with electric resistance heating, AC with gas heating, heat pumps and residences with heating but no AC. The deemed savings are based on the R-value of the ceiling insulation pre-retrofit and a combined post-retrofit R-value (R-values of the existing insulation and the insulation being added) of at least R-38. Savings are also provided for R-49, and linear interpolation may be used to claim savings for final R-values between R-38 and R-49.

Note that the savings per square foot is a factor to be multiplied by the square footage of the ceiling area over a conditioned space that is being insulated.

For deemed savings for installation between the range of R-38 to R-49, linear interpolation can be used to determine the value that can be claimed as savings.

When providing per-residence estimates, we have included the following parameters from the PY6 Home Performance with Energy Star Program:

- Average project size: 1,633 square feet
- Average baseline: R - 0.85[290]

Table C-94: Deemed Savings for R-30 – Per-Residence

AC/Gas Heat kWh	AC/Electric Resistance kWh	Heat Pump kWh	No AC/Electric Resistance kWh	AC Peak Savings (kW)
(/ residence)	(/ residence)	(/ residence)	(/ residence)	(/ residence)
1,841	4,697	2,343	2,856	9.335

Table C-95: Deemed Savings for R-38 – Per-Residence

AC/Gas Heat kWh	AC/Electric Resistance kWh	Heat Pump kWh	No AC/Electric Resistance kWh	AC Peak Savings (kW)
(/ residence)	(/ residence)	(/ residence)	(/ residence)	(/ residence)
1,879	4,798	2,393	2,919	9.480

Table C-96: Deemed Savings for R-49 – Per-Residence

AC/Gas Heat kWh	AC/Electric Resistance kWh	Heat Pump kWh	No AC/Electric Resistance kWh	AC Peak Savings (kW)
(/ residence)	(/ residence)	(/ residence)	(/ residence)	(/ residence)
1,931	4,937	2,463	3,005	9.681

[290] 83% of projects in PY6 had R-0 baseline. Contractors in the HPwES Program have demonstrated that they do not install insulation on lower-return projects (such as R-9 or above)

C.4.2.5. Calculation of Deemed Savings

BEopt™ was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine; available TMY3 weather data specific to the New Orleans area was used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

C.4.2.5.1. Energy Savings

$$Savings_{kWh} = Installed\ Square\ Footage \times \left[(I_1 \times R_{Final}) + \left(C_1 \times {R_{initial}}^4\right) + \left(C_2 \times {R_{initial}}^3\right) + \left(C_3 \times {R_{initial}}^2\right) + (C_4 \times R_{initial}) + I_2\right]$$

Where:

Installed Square Footage = Total installed square footage of insulation

R_{final} = Ending R-value of insulation

$R_{initial}$ = Starting R-value of insulation

I_1, I_2, C_1, C_2, C_3, C_4 = Coefficients as found in Table C-97 below

Table C-97: Coefficients for kWh Savings Calculations

Coefficients for Energy Savings				
Coefficients	***AC/Gas Heat***	***AC/Electric Resistance***	***Heat Pump***	***No AC/Electric Resistance***
I_1	3.189E-03	8.412E-03	4.211E-03	5.224E-03
C_1	1.431E-05	2.810E-05	1.214E-05	1.379E-05
C_2	-8.743E-04	-1.812E-03	-8.110E-04	-9.377E-04
C_3	2.041E-02	4.517E-02	2.102E-02	2.476E-02
C_4	-2.388E-01	-5.693E-01	-2.754E-01	-3.305E-01
I_2	1.3226	3.3375	1.6578	2.0149

Rounding is not permitted.

C.4.2.5.2. Demand Savings

$$Savings_{kW} = Installed\ Square\ Footage \times \left[(I_1 \times R_{Final}) + \left(C_1 \times {R_{initial}}^6\right) + \left(C_2 \times {R_{initial}}^5\right) + \left(C_3 \times {R_{initial}}^4\right) + \left(C_4 \times {R_{initial}}^3\right) + \left(C_5 \times {R_{initial}}^2\right) + (C_6 \times R_{initial}) + I_2\right]$$

Where:

Installed Square Footage = Total installed square footage of insulation

R_{final} = Ending R-value of insulation

$R_{initial}$ = Starting R-value of insulation

I_1, I_2, C_1, C_2, C_3, C_4, C_5, C_6 = Coefficients as found in Table C-98 below

Table C-98: Coefficients for kW Savings Calculations

Coefficients for Demand Savings				
Coefficients	**AC/Gas Heat**	**AC/Electric Resistance**	**Heat Pump**	**No AC/Electric Resistance**
I_1	1.246E-05	1.246E-05	1.157E-05	5.637E-06
C_1	3.789E-09	3.789E-09	3.773E-09	1.817E-09
C_2	-2.871E-07	-2.871E-07	-2.861E-07	-1.393E-07
C_3	8.571E-06	8.571E-06	8.549E-06	4.234E-06
C_4	-1.281E-04	-1.281E-04	-1.279E-04	-6.509E-05
C_5	1.008E-03	1.008E-03	1.009E-03	5.376E-04
C_6	-4.137E-03	-4.137E-03	-4.148E-03	-2.397E-03
I_2	8.709E-03	8.709E-03	8.786E-03	5.658E-03

Rounding is not permitted.

C.4.2.6. Incremental Cost

The incremental cost for this measure is the total cost. The cost is $0.035 per sq. ft. per "R" unit of insulation[291]. For the average project size of 1,633 square feet, the resulting cost is:

- R-30: $1,109[292]
- R-38: $2,172
- R-49: $2,801

C.4.2.7. Future Studies

This measure should have its simulation model recalibrated to the billed use of the past three years of program participants.

If there is adequate participation, the assumed default square foot value should be revised.

[291] Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

[292] R-30 IC based on PY7 and PY8 ENO program data.

C.4.3. Wall Insulation

C.4.3.1. Measure Description

This measure consists of adding wall insulation in the wall cavity in residential dwellings of existing construction. This measure applies to all residential applications.

C.4.3.2. Baseline and Efficiency Standards

In order to qualify for this measure, there must be no existing wall cavity insulation. Post-retrofit condition will be a wall cavity filled with either fiberglass or cellulose insulation (R-13 nominal value), open cell insulation (R-13 nominal value), or closed cell foam insulation (R-23 nominal value). Each type of insulation's nominal R-value depends on a full thickness application within the cavity of a wall with 2x4 inch studs.

Table C-99: Wall Insulation – Baseline and Efficiency Standards

Baseline	***Efficiency Standard (Nominal R-Values)***	
Uninsulated wall cavity	Fiberglass/Cellulose	R-13
	Open Cell Foam	R-13
	Closed Cell Foam	R-23

C.4.3.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 20 years, according to DEER 2014.

C.4.3.4. Deemed Savings

The savings per square foot is a factor to be multiplied by the square footage of the net wall area insulated. Wall area must be part of the thermal envelope of the home and shall not include window or door area.

Deemed savings for R-13 can be achieved with either fiberglass, cellulose, or open cell foam insulation. Deemed savings for R-23 is only applicable to closed cell insulation. The R-value represents the nominal value of the cavity insulation and not the R-value of the wall assembly.

For deemed savings for installation between the range of R-13 to R-23, linear interpolation can be used to determine the value that can be claimed as savings.

To calculate savings per-residence, the following assumptions are used:

- Average square feet of insulation: 1,501[293]

[293] ENERGY STAR guidance. https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Savings_and_Cost_Estimate_Summary.pdf

Table C-100: Wall Insulation – Deemed Savings Values Per-Residence

Ceiling Insulation Base R-Value	kWh Savings / sq. ft.		kW Peak Savings / sq. ft.	
	R-13	R-23	R-13	R-23
Electric Cooling with Gas Heat	0.78286	0.82574	0.00033	0.00060
Electric Cooling with Electric Resistance Heat	3.33772	3.74885	0.00033	0.00060
Electric Cooling with Electric Heat Pump	1.05252	1.13064	0.00033	0.00051

Table C-101: Wall Insulation – Deemed Savings Values Per-Ft.^{2}

Ceiling Insulation Base R-Value	kWh Savings / sq. ft.		kW Peak Savings / sq. ft.	
	R-13	R-23	R-13	R-23
Electric Cooling with Gas Heat	0.78286	0.82574	0.00033	0.00060
Electric Cooling with Electric Resistance Heat	3.33772	3.74885	0.00033	0.00060
Electric Cooling with Electric Heat Pump	1.05252	1.13064	0.00033	0.00051

C.4.3.5. Calculation of Deemed Savings

Deemed savings values have been calculated for each of the four weather zones. The deemed savings are dependent on the R-value of the wall pre- and post-retrofit. BEopt™ was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since wall insulation savings are sensitive to weather, available TMY3 weather data specific to each of the four Arkansas weather regions were used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

C.4.3.6. Incremental Cost

The incremental cost of this measure is equal to the full installed cost. If this is not available, use $.92 per square foot.[294]. For the average project size of 1,501 square feet, this results in an incremental cost of $1,381.

[294] Midpoint value for floor insulation specified on Home Advisor. http://www.homeadvisor.com/cost/insulation/

C.4.3.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values based on simulation results. If this measure is added to Energy Smart programs and exceeds 1% of residential savings, then the simulation model should be updated to align with the billed use of customers that install the measure.

If there is adequate participation, the assumed default square foot value should be revised.

C.4.4. Floor Insulation

C.4.4.1. Measure Description

This measure presents two eligible scenarios for retrofitting a crawl space underneath an uninsulated floor[295]:

1. Insulating the underside of the floor (above the vented crawl space), where the floor previously had no insulation
2. "Encapsulating" the crawl space – sealing and insulating the vented perimeter skirt or stem wall between the ground (finished grade) and the first floor of the house, leaving the underside of the first floor structure uninsulated

This measure applies to all residential applications.

C.4.4.2. Baseline and Efficiency Standards

The baseline is considered to be a house with pier and beam construction, no insulation under the floor of the conditioned space, and a vented crawl space. In order to qualify for deemed savings, either the floor can be insulated to a minimum of R-19 or the crawl space can be encapsulated as described below. Deemed savings are provided for each option.

- Option 1 – Insulating the underside of the floor to a minimum of R-19.
- Option 2 – Encapsulating the crawl space: The crawl space perimeter skirt or stem walls are sealed in a sound and durable manner and the ground (floor of the crawl space) is sealed with a heavy plastic vapor barrier. The skirt or stem wall interior surfaces are insulated to R-13 (minimum) with closed cell foam[296]. The underside of the floor above the crawlspace is left uninsulated. A small flow of conditioned air to the crawl space is recommended to moderate humidity levels[297].

Occupational Safety and Health Administration (OSHA) standards and applicable versions of the IECC and IRC codes will be pertinent to the installation. Note that this will include ensuring that any oil or gas-fueled furnaces or water heaters located in the crawlspace be provided with dedicated combustion air supply or be sealed-combustion units equipped with a powered combustion system.[298]

[295] U.S. DOE publication *"Building America Best Practices Series, Vol 17, "Insulation*" found at http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/insulation_guide.pdf (accessed 7-8-15) has extensive building science and code conformance information regarding insulating floors as well as sealing and insulating crawl spaces.

[296] IECC 2012, Table R402.1

[297] U.S. DOE publication "*Building America Best Practices Series, Vol 17, "Insulation*" found at http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/insulation_guide.pdf (accessed 7-8-15), p. 58, 1 cfm per every 50 sq. ft. of floor area.

[298] Ibid (p. 59).

Table C-102: Floor Insulation – Baseline and Efficiency Standards

Baseline	Efficiency Standard
No insulation under floor	(1) R-19 installed under floor, OR (2) Encapsulated crawl space with air-sealed perimeter having R-13 insulation on the interior side, no floor insulation under the floor above, and moisture-sealed grade under the crawl space

C.4.4.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 20 years, according to DEER 2014.

C.4.4.4. Deemed Savings Values

The deemed savings values listed below are per square foot of first level floor area above the crawl space.

For the per-residence savings, we assume the same square feet as attic insulation (1,633 ft.^{2}), due to a lack of participation in this measure. This is to be updated when there is adequate participation to support an estimate.

Table C-103: R-19 Floor Insulation – Deemed Savings Values Per-Residence

Equipment Type	kWh Savings / residence	kW Peak Savings / residence
Electric Cooling with Gas Heat	-393.226	Negligible
Electric Cooling with Electric Resistance Heat	108.5945	n/a
Electric Cooling with Electric Heat Pump	807.5185	Negligible

Table C-104: R-19 Floor Insulation – Deemed Savings Values Per-Ft.^{2}

Equipment Type	kWh Savings / sq. ft.	kW Peak Savings / sq. ft.
Electric Cooling with Gas Heat	-0.2408	Negligible
Electric Cooling with Electric Resistance Heat	0.4945	Negligible
Electric Cooling with Electric Heat Pump	0.0952	Negligible

C.4.4.5. Calculation of Deemed Savings

Deemed savings values have been calculated for each of the four weather zones. BEopt™ was used to estimate energy savings for both options using the same base case model (uninsulated floor) and the DOE EnergyPlus simulation engine. Savings are sensitive to weather; therefore, available TMY3 weather data specific to New Orleans used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

C.4.4.6. Incremental Cost

The incremental cost of this measure is equal to the full installed cost.

C.4.4.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values based on simulation results. If this measure is added to Energy Smart programs and exceeds 1% of residential savings, then the simulation model should be updated to align with the billed use of customers that install the measure.

If there is adequate participation, the assumed default square foot value should be revised.

C.4.5. ENERGY STAR® Windows, Doors and Skylights

C.4.5.1. Measure Description

This measure involves the replacement of windows with an ENERGY STAR® window(s), door(s) or skylight(s) in an existing home. This measure applies to all residential applications and are calculated on per square foot of window basis, inclusive of frame and sash. All windows must be in a metal frame. Converted residences are not eligible.

ENEGRY STAR® U-factor and Solar Heat Gain Coefficient (SHGC) qualification criteria vary based on climate zone. Figure C-11 displays the fours zones, with New Orleans appearing in the 'Southern' zone. Relevant required efficiency levels are shown in Table C-105.

Figure C-11: ENERGY STAR® Window Program Climate Map

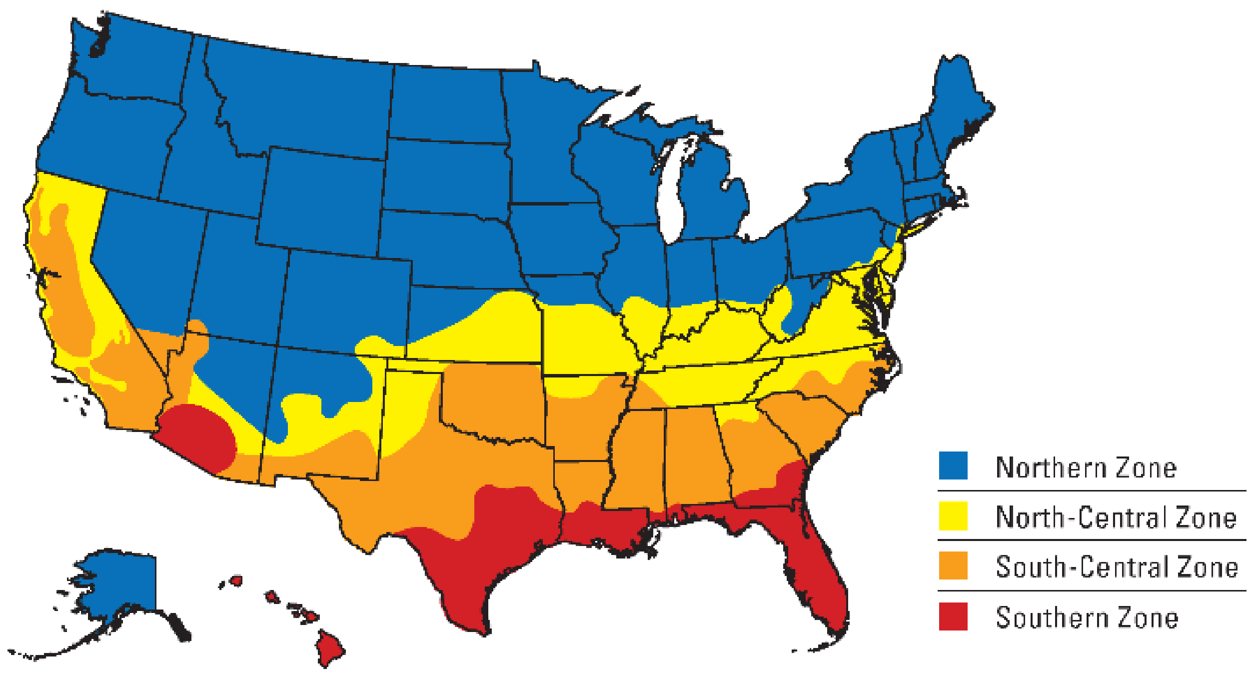

Table C-105: ENERGY STAR® Efficiency Requirements for New Orleans[299]

New Orleans - Southern	U-Factor[300]	SHGC[301]
Windows	≤ 0.40	≤ 0.25
Doors (Opaque)	≤ 0.17	No Rating
Doors (≤ ½ Glass)	≤ 0.25	≤ 0.25
Doors (> ½ Glass)	≤ 0.30	≤ 0.25
Skylights	≤ 0.60	≤ 0.28

C.4.5.2. Baseline and Efficiency Standards

For this measure, there are two separate baseline assumptions and two sets of deemed savings values for both single and double pane windows. Prototypical U-Values and SHGCs for baseline windows are presented in Table C-106.

Table C-106: Baseline Windows

Number of Panes	U-Factor Btu/ (h*ft2 *°F)	Solar Heat Gain Coefficient (SHGC)
1	1.12	0.79
2	0.81	0.64

C.4.5.3. Estimated Useful Life (EUL)

The lifetime of an ENERGY STAR® window is 20 years[302].

C.4.5.4. Deemed Savings

C.4.5.4.1. Windows

Table C-107 and Table C-108 provide per-square foot deemed savings values for single pane and double pane windows.

[299] Effective as of January 1, 2016. https://www.energystar.gov/sites/default/files/asset/document/Windows_Doors_and_Skylights_Program_Requirements%20v6.pdf

[300] Btu/(h*ft2 *°F)

[301] Solar Heat Gain Coefficient

[302] DEER 2008, 2014.

Table C-107: ENERGY STAR® Replacement for Single-Pane Window[303]

Equipment Type	kWh Savings / sq. ft.	kW Savings / sq. ft.
Electric AC with Gas Heat	5.847	0.0024
Elec. AC with Resistance Heat	6.149	0.0024
Heat Pump	5.975	0.0024

Table C-108: ENERGY STAR® Replacement for Double-Pane Window[304]

Equipment Type	kWh Savings / sq. ft.	kW Savings / sq. ft.
Electric AC with Gas Heat	3.931	0.0017
Elec. AC with Resistance Heat	3.990	0.0017
Heat Pump	4.035	0.0017

Table C-109 and Table C-110 show savings for a typical window, 11.06 ft^2 (approximately 35.6” x 44.5”).[305]

Table C-109: Average Savings for Single-Pane Windows

Equipment Type	kWh Savings	kW Savings
Electric AC with Gas Heat	64	0.027
Elec. AC with Resistance Heat	68	0.027
Heat Pump	66	0.027

Table C-110: Average Savings for Double-Pane Windows

Equipment Type	kWh Savings	kW Savings
Electric AC with Gas Heat	43	0.019
Elec. AC with Resistance Heat	44	0.019
Heat Pump	44	0.019

C.4.5.4.2. Doors

Table C-111 through Table C-113 provide per-square foot deemed savings values for doors.

303 Modeled at 202 ft^2 area

304 Modeled at 202 ft^2 area

305 Based on an inventory of the 100 highest-selling windows in local stores.

Table C-111: ENERGY STAR® Replacement for Doors (Opaque) [306]

Equipment Type	kWh Savings / sq. ft.	kW Savings / sq. ft.
Electric AC with Gas Heat	0.725	0.0171
Elec. AC with Resistance Heat	3.725	0.0171
Heat Pump	1.750	0.0171

Table C-112: ENERGY STAR® Replacement for Doors (≤ ½-Lite) [307]

Equipment Type	kWh Savings / sq. ft.	kW Savings / sq. ft.
Electric AC with Gas Heat	1.400	0.0262
Elec. AC with Resistance Heat	4.100	0.0262
Heat Pump	2.275	0.0262

Table C-113: ENERGY STAR® Replacement for Doors (> ½-Lite) [308]

Equipment Type	kWh Savings / sq. ft.	kW Savings / sq. ft.
Electric AC with Gas Heat	3.000	0.0523
Elec. AC with Resistance Heat	6.225	0.0523
Heat Pump	4.175	0.0523

C.4.5.4.3. Skylights

Table C-114 provides per-square foot deemed savings values for skylights.

Table C-114: ENERGY STAR® Replacement for Skylights[309]

Equipment Type	kWh Savings / sq. ft.	kW Savings / sq. ft.
Electric AC with Gas Heat	0.842	0.0322
Elec. AC with Resistance Heat	0.842	0.0322
Heat Pump	0.901	0.0322

BEopt™ was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since ENERGY STAR® window, skylight and door

[306] 40 ft^2 area, no glass

[307] 40 ft^2 area, 25% glass

[308] 40 ft^2 area, 75% glass

[309] 101 ft^2 area

savings are sensitive to weather, available TMY3 weather data specific to New Orleans was used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

C.4.5.5. Incremental Costs

Windows: ENERGY STAR®[310] estimates window incremental costs for the New Orleans climate zone to be $0.61/ft^2, or $6.74 for a typical 11.06ft^2 window.

Doors: ENERGY STAR®[311] estimates incremental costs for doors to be $13 for ≤ 1/2 lite doors and $30 for >1/2 lite doors. The average cost increase over best-selling opaque doors is $0, thus the incremental cost for opaque doors is $0.

Skylights: ENERGY STAR®[311] estimates incremental costs for skylights to be $20-$40 for a typical skylight.

C.4.5.6. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure has not yet been implemented in Energy Smart programs. As a result, savings are calculated using Texas values which have been weather-normalized for New Orleans. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents.

If participation reached 1% of residential Energy Smart program savings, the TPE recommends a simulation models be calibrated with utility metering data and deemed savings estimates be updated at that time.

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[310] https://www.energystar.gov/sites/default/files/asset/document/Savings_and_Cost_Estimate_Summary.pdf

[311] https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/windows_doors/Draft6_V1_Criteria_Analysis_Report.pdf

C.4.6. ENERGY STAR® Low Emissivity Storm Windows

C.4.6.1. Measure Description

This measure involves the installation of interior or exterior ENERGY STAR® low emissivity (low-e) storm windows over existing windows. Savings is achieved through lowering structure emissivity, solar gain and air leakage. This measure applies residential applications including low-rise multifamily buildings. ENEGRY STAR® U-factor and Solar Heat Gain Coefficient (SHGC) qualification criteria vary based on climate zone. Figure C-11 displays the fours zones, with New Orleans appearing in the 'Southern' zone. Relevant required efficiency levels are shown in Figure C-12.

Figure C-12: ENERGY STAR® Window Program Climate Map

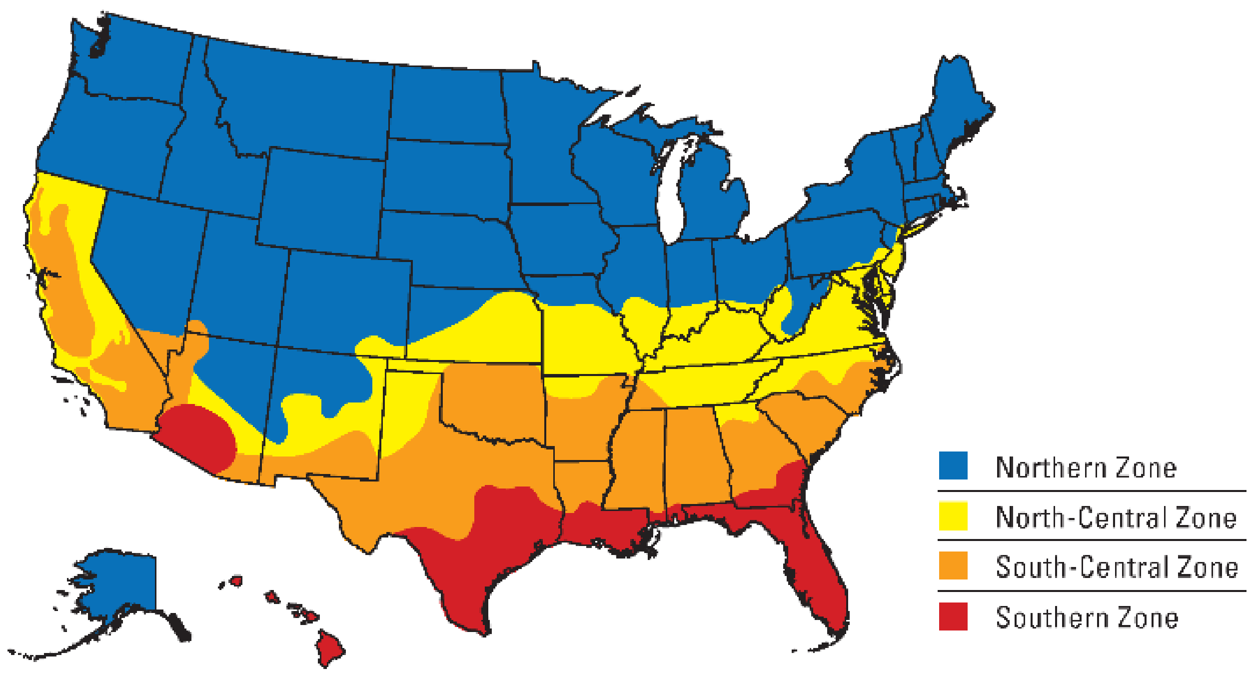


Table C-115: ENERGY STAR® Requirements for Storm Windows (Southern Region)

Emissivity	***Solar Transmission***	***Air Leakage***
≤ 0.22	≤ 0.55	≤ 1.5 (exterior) ≤ 0.5 (interior)

C.4.6.2. Baseline and Efficiency Standards

The baseline for this measure is an existing single or double pane glass window with no existing storm window.

C.4.6.3. Estimated Useful Life (EUL)

The lifetime of an ENERGY STAR® window is 20 years[312].

C.4.6.4. Deemed Savings

Table C-116 and Table C-117 provide deemed savings values for interior and exterior ENERGY STAR® storm windows.

Table C-116: ENERGY STAR® Interior Storm Window Deemed Savings

Equipment Type	kWh Savings/ ft.^{2}	kW Savings/ ft.^{2}
Gas & AC	1.51	0.0007
AC & Elec Resistance	2.98	0.0007
Heat Pump	1.96	0.0007

Table C-117: ENERGY STAR® Exterior Storm Window Deemed Savings

Equipment Type	kWh Savings/ ft.^{2}	kW Savings/ ft.^{2}
Gas & AC	1.38	0.0006
AC & Elec Resistance	2.10	0.0006
Heat Pump	1.62	0.0006

BEopt™ was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since ENERGY STAR® storm window savings are sensitive to weather, available TMY3 weather data specific to New Orleans was used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

C.4.6.5. Incremental Costs

The incremental cost of this measure is equal to the full installed cost. If this is not available, the incremental costs for low-E storm windows are assumed to be $1/sqft[313].

C.4.6.6. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure has not yet been implemented in Energy Smart programs. As a result, savings are calculated using national values which have been weather-normalized for New Orleans. If this measure

[312] DEER 2008, 2014.

[313] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24826.pdf

is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans residents.

If participation reached 1% of residential Energy Smart program savings, the TPE recommends running simulation models be calibrated with utility metering data and deemed savings estimates be updated at that time.

C.4.7. Air Infiltration

C.4.7.1. Measure Description

This measure reduces air infiltration into the residence, using pre- and post-treatment blower door air pressure readings to quantify the air leakage reduction. There is no post-retrofit minimum infiltration requirement, however, installations must comply with the prevailing Arkansas mechanical code. This measure applies to all residential applications.

C.4.7.2. Baseline and Efficiency Standards

The baseline for this measure is the existing leakage rate of the residence to be treated. The existing leakage rate should be capped to account for the fact that the deemed savings values per CFM50 leakage reduction are only applicable up to a point where the existing HVAC equipment would run continuously. Beyond that point, energy use will no longer increase linearly with an increase in leakage.

Baseline assumptions used in the development of these deemed savings are based on the *2013 ASHRAE Handbook of Fundamentals, Chapter 16*, which provides typical infiltration rates for residential structures. In a study of low income homes reported in ASHRAE, approximately 95 percent of the home infiltration rates were below 3.0 ACH_{Nat}.[314] Therefore, to avoid incentivizing homes with envelope problems not easily remedied through typical weatherization procedures, or improperly conducted blower door tests, these savings should only be applied starting at a baseline ACH_{Nat} of 3.0 or lower.

To calculate the maximum allowable $CFM_{50,pre}$-value for a particular house, use the following equation:

$$CFM_{50,pre}/ft^2 = \frac{ACH_{Nat,pre} \times h \times N}{60}$$

Where:

$CFM_{50,pre}/ft^2$ = Per square foot pre-installation infiltration rate (CFM50/ft2)

$ACH_{Nat,pre}$ = Maximum pre-installation air change rate (ACH_{Nat}) = 3.0

60 = Constant to convert from minutes to hours

h = Ceiling height (ft.) = 8.5 (default)315

N = N factor (Table C-118:)

[314] 2013 ASHRAE Handbook of Fundamentals, Chapter 16, pp. 16.18, Figure 12.

[315] Typical ceiling height of 8 feet adjusted to account for greater ceiling heights in some areas of a typical residence.

Table C-118: Air Infiltration – N Factor[316]

Wind Shielding	Number of Stories		
	Single Story	**Two Story**	**Three + Story**
Well Shielded	25.8	20.6	18.1
Normal	21.5	17.2	15.1
Exposed	19.4	15.5	13.5

Well Shielded is defined as urban areas with high buildings or sheltered areas, and buildings surrounded by trees, bermed earth, or higher terrain.

Normal is defined as buildings in a residential neighborhood or subdivision, with yard space between buildings. Approximately 80-90 percent of houses fall in this category.

Exposed is defined as buildings in an open setting with few buildings or trees around and buildings on top of a hill or ocean front, exposed to winds.

Maximum CFM_{50} per square foot values are available in Table C-119. Pre-retrofit leakage rates are limited to fa maximum per $ft.^2$ value specified in the table, as this generally indicates severe structural damage not repairable by typical infiltration reduction techniques.

Table C-119: Pre-Retrofit Infiltration Cap (CFM_{50}/ft^2)

Wind Shielding	Number of Stories		
	Single Story	**Two Story**	**Three + Story**
Well Shielded	11.0	8.8	7.7
Normal	9.1	7.3	6.4
Exposed	8.2	6.6	5.7

C.4.7.3. Estimated Useful Life (EUL)

According to DEER 2014, the Estimated Useful Life for air infiltration is 11 years.

C.4.7.4. Deemed Savings Values

Programs should calculate savings based on pre- and post-retrofit leakage testing. If this data is not available, default estimates may be applied. The following assumptions based

[316] Krigger, J. & Dorsi, C. 2005, Residential Energy: Cost Savings and Comfort for Existing Buildings, 4th Edition. Version RE. Appendix A-11: Zone 3 Building Tightness Limits, p. 284., December 20. www.waptac.org/data/files/Website_docs/Technical_Tools/Building%20Tightness%20Limits.pdf.

on PY6 evaluation results of the Home Performance with ENERGY STAR Program are used in providing per-residence savings estimates:

- Leakage reduction: 2,045 CFM

Table C-120: Air Infiltration Reduction – Deemed Savings Values Per-Residence

Equipment Type	***kWh Savings / CFM_{50} (ESF)***	***kW Savings / CFM_{50} (DSF)***
Electric AC with Gas Heat	840	0.6769
Elec. AC with Resistance Heat	2,082	0.6789
Heat Pump	1,474	0.6789

C.4.7.5. Deemed Savings Calculations

The following formulas shall be used to calculate deemed savings for infiltration efficiency improvements. The formulas apply to all building heights and shielding factors.

$$kWh_{savings} = CFM_{50} \times ESF$$

$$kW_{savings} = CFM_{50} \times DSF$$

Where:

CFM_{50} = Air infiltration reduction in Cubic Feet per Minute at 50 pascals, as measured by the difference between pre- and post-installation blower door air leakage tests

ESF = corresponding energy savings factor (Table C-121)

DSF = corresponding demand savings factor (Table C-121)

Table C-121: Air Infiltration Reduction – Deemed Savings Values Per-Ft.[2]

Equipment Type	***kWh Savings / CFM_{50} (ESF)***	***kW Savings / CFM_{50} (DSF)***
Electric AC with Gas Heat	0.4108	0.000331
Elec. AC with Resistance Heat	1.018	0.000332
Heat Pump	0.721	0.000332

C.4.7.6. Calculation of Deemed Savings

BEopt™ was used to estimate energy savings for a series of models using the US DOE EnergyPlus simulation engine. Since infiltration savings are sensitive to weather, available TMY3 weather data specific to New Orleans was used for the analysis. The prototype home characteristics used in the BEopt™ building model are outlined in Appendix A.

The deemed savings are dependent on the pre- and post-CFM_{50} leakage rates of the home and are presented as annual savings / CFM_{50} reduction. A series of model runs was completed in order to establish the relationship between various CFM_{50} leakage rates and heating and cooling energy consumption. The resulting analysis of model outputs was used to create the deemed savings tables of kWh and kW per CFM_{50} of air infiltration reduction.

C.4.7.7. Incremental Cost

The incremental cost of this measure is equal to the full installed cost. If this is not available, a default value of $.25 per square foot of conditioned floor area may be applied[317]. This should use a default of 1,762 square feet, based on PY6 program tracking for the Home Performance with ENERGY STAR Program.

The resulting per-project incremental cost is $441.

C.4.7.1. Net-to-Gross Ratio

The NTGR for this measure is 95%[318].

C.4.7.2. Future Studies

This measure is a High Impact Measure, having constituted 13.3% of PY6 program savings. To-date, the evaluations have not conducted significant primary research on this measure due to the focusing of EM&V budget on Residential Lighting and Residential HVAC studies.

This measure should have its simulation model recalibrated to the billed use of the past three years of program participants.

[317] ENERGY STAR guidance. https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Savings_and_Cost_Estimate_Summary.pdf

[318] Based on primary data collection from 78 PY6-9 program participants.

C.4.8. Window Film

C.4.8.1. Measure Description

This measure consists of adding solar film to east and west facing windows. This measure applies to all residential applications.

C.4.8.2. Baseline and Efficiency Standards

This measure is applicable to existing homes only. Low E windows and tinted windows are not applicable for this measure. In order to qualify for deemed savings, solar film should be applied to east and west facing glass.

Table C-122: Window Film – Baseline and Efficiency Standards

Baseline	***Efficiency Standard***
Single- or double-pane window with no existing solar films, solar screens, or low-e coating	Solar Film with SHGC <0.50

C.4.8.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2014.

C.4.8.4. Deemed Savings Values

Please note that the savings per square foot is a factor to be multiplied by the square footage of the window area to which the films are being added.

For the per-residence values, we assume 330 total window square feet[319].

[319] ENERGY STAR guidance. https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Savings_and_Cost_Estimate_Summary.pdf

Table C-123: Window Film – Deemed Savings Values Per-Residence

Existing Windowpane Type	AC/Gas Heat kWh	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings (kW)
	(/ residence)	(/ residence)	(/ residence)	(/ residence)
Single Pane	1,391	-218	531	0.33
Double Pane	813	-75	273	0.33

Table C-124: Window Film – Deemed Savings Values Per-Ft.^{2}

Existing Windowpane Type	AC/Gas Heat kWh	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings (kW)
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
Single Pane	4.216	-0.661	1.610	0.001
Double Pane	2.465	-0.226	0.826	0.001

C.4.8.5. Calculation of Deemed Savings

Deemed savings values have been calculated for each of the four weather zones. The deemed savings are dependent on the SHGC of pre- and post-retrofit glazing. BEopt™ was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since window film savings are sensitive to weather, available TMY3 weather data specific to New Orleans was ere used for the analysis. The prototype home characteristics used in the BEopt building model are outlined in Appendix A.

C.4.8.6. Incremental Cost

The incremental cost of this measure is equal to the full installed cost. If this is not available, the default cost is:

- $2.00 per square foot[320]
- $660 per residence

C.4.8.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values based on simulation results. If this measure is added to Energy Smart programs

[320] Energize Connecticut cost documentation. http://www.uinet.com/wps/wcm/connect/193bba80476e1bc19d6c9d02c80795ac/FINAL-C0118-2017-UI-CI-Incentive-Matrix-Gas-Caps-Rev.+02.17.pdf?MOD=AJPERES&CACHEID=193bba80476e1bc19d6c9d02c80795ac

and exceeds 1% of residential savings, then the simulation model should be updated to align with the billed use of customers that install the measure.

If there is adequate participation, the assumed default square foot value should be revised.

C.4.9. Radiant Barriers

C.4.9.1. Measure Description

Radiant barriers are designed to block radiant heat transfer between a building roof and the attic space insulation. They typically consist of a metallic foil material (usually aluminum) and are generally installed on the roof decking or beneath roof sheathing. Radiant barriers are most effective at reducing cooling consumption by reflecting heat away from a home.

C.4.9.2. Baseline and Efficiency Standards

This measure applies to existing construction that does not have a radiant barrier installed on the roof decking.

The efficiency requirements for radiant barriers must meet the standards set by the Reflective Insulation Manufacturers Association International (RIMA) to include proper attic ventilation. The following table displays the requirements for radiant barriers:

Table C-125: Required Substantiation

Required Substantiation		
Physical Property	***Test Method or Standard***	***Requirement***
Surface Emittance	ASTM C 1371	0.1 or less
Water Vapor Transmission	ASTM E 96: Procedure A Desiccant Method	0.02 for Vapor Retarder 0.5 or greater for perforated products
Surface Burning		
Flame Spread	ASTM E 84	25 or less
Smoke Density	ASTM E 84	450 or less
Corrosivity	ASTM D 3310	Corrosion on less than 2% of the affected surface
Tear Resistance	ASTM D 2261	
Adhesive Performance		
Bleeding	Section 10.1 of ASTM C 1313	Bleeding or delamination of less than 2% of the surface area
Pliability	Section 10.2 of ASTM C 1313	No cracking or delamination
Mold and Mildew	ASTM C 1338	No growth when visually examined under 5X magnification

Interior radiation control coatings are not applicable for the deemed savings derived. A study performed by RIMA found that none of the coating-type products currently on the market had an emittance of 0.10 or lower as required by the standards set by the American Society for Testing and Materials (ASTM) for a product to be considered a radiant barrier.[321] Therefore, all coating materials and spray application materials are ineligible for application of these savings values.

All radiant barriers should be installed according to the RIMA Handbook, Section 7.4.[322] However, horizontal installation is not eligible, due to the likelihood of dust buildup and wear-and-tear damage to the radiant barrier.

A radiant barrier cannot be in contact with any other materials on its underside or else it becomes defective. Therefore, once a radiant barrier is installed on the roof decking, no roof deck insulation can be installed.

C.4.9.3. Estimated Useful Life (EUL)

The average lifetime of this measure is estimated to be about 25 years for downward facing radiant barriers, based on the DOE's Radiant Barrier Fact Sheet.[323]

C.4.9.4. Deemed Savings Values

Deemed savings values have been calculated for New Orleans. The calculations for deemed savings values are based on the addition of a radiant barrier to the roof decking where a radiant barrier did not previously exist. Please note that the savings per square foot is a factor to be multiplied by the square footage of the ceiling area over a conditioned space to which the radiant barrier is applied. Gas Heat (no AC) kWh applies to forced air furnace systems only.

Table C-126: Deemed Savings Values

Savings Values					
Addition of Radiant Barrier with existing attic insulation level	AC/Gas Heat kWh	Gas Heat (no AC) kWh	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
Attic insulation ≤R-19	0.2142	0.006	0.3238	0.1794	0.0001
Attic insulation >R19	0.1361	0.0039	0.1853	0.0993	0.0001

C.4.9.5. Incremental Cost

The incremental cost is \$0.15 to \$0.45 per square feet.[324]

[321] Study by RIMA that found no radiant coating on the market having a low enough emittance to be considered a radiant barrier: http://www.rimainternational.org/technical/ircc.html

[322] RIMA Handbook available online: http://www.rimainternational.org/technical/handbook.html

[323] http://web.ornl.gov/sci/ees/etsd/btric/RadiantBarrier/RBFactSheet2010.pdf

[324] Oak Ridge National Laboratory. https://web.ornl.gov/sci/buildings/tools/radiant/rb2/rb-tables/index.shtml#table1

C.5. Residential Lighting

C.5.1. Residential Lighting Efficiency

C.5.1.1. Measure Description

A variety of high-efficiency fixtures, ballasts and lamps exist in the market today, producing the same lighting level (in lumens) as their standard-efficiency counterparts while consuming less electricity. This measure provides energy and demand savings calculations for the replacement of residential lighting equipment with energy efficient lamps or fixtures. The operating hours and demand factors are based on primary research in the New Orleans market.

C.5.1.2. Baseline

The baseline equipment is assumed to be an incandescent or halogen lamp with adjusted baseline wattages compliant with EISA 2007 regulations dictate higher efficiency baseline lamps.

The first Tier of EISA 2007 regulations were phased in from January 2012 to January 2014. Beginning January 2012, a typical 100W lamp wattage was reduced to comply with a maximum 72W lamp wattage standard for a rated lumen output range of 1,490-2,600 lumens. Beginning January 2013, a typical 75W lamp wattage was reduced to comply with a maximum 53W lamp wattage standard for a rated lumen output range of 1,050-1,489 lumens. Beginning January 2014, typical 60W and 40W lamp wattages were reduced to comply with maximum 43W and 29W lamp wattage standards for rated lumen output ranges of 750-1,049 and 310-749 lumens.

The second Tier of EISA 2007 regulations go into effect beginning January 2020. At that time, general service lamps must comply with a 45 lumen per watt efficacy standard. Since the EUL of some lamps in this measure extend beyond that date, the baseline should be adjusted to the second Tier for any years after 2022.[325]

Specific baselines are discussed in individual lighting measure chapters.

C.5.1.3. Efficiency Standard

Lamps must be a standard ENERGY STAR® qualified lighting.

Exceptions to the ENERGY STAR® label are allowed for unlisted lamps, fixtures or other lighting-related devices that have been submitted to ENERGY STAR® for approval. If the lamp or fixture does not achieve ENERGY STAR® approval within the New Orleans

[325] First tier EISA compliant halogens have a lifetime of 4 years (3,000 hours at 2.17 hours per day). The last year these lamps are available is 2019, and they will need replacement at the end of 2022. Thus, the new standard must be used after 2022.

program year, however, then the lamp or fixture would have to be immediately withdrawn from the program.

C.5.1.4. Lighting Hours of Use (HOU) Metering

Hours of use were estimated through direct monitoring of lighting in the on-site sample homes. Each logger was extrapolated to full annual usage by using a linear model with day length as the predictor, where day length varies inversely with the number of hours of use. Latitude and longitude coordinates for New Orleans, Louisiana were used in the computation of day length (29.9511, -90.0715). The regression used to extrapolate the meter data to a full year is shown in the equation below.

$$H_d = \alpha + \beta * \text{Day Length} + \varepsilon_d$$

Where:

H_d = hours of use on day d

Day Length = Number of daylight hours on day d

α and β are coefficients determined by the regression

ε_d = residual error.

A similar model was run which added room type as an explanatory variable in order to estimate hours of use for each room type.

C.5.1.4.1. Hours of Use Results

Results of the regressed logger data provided the TPE with overall efficient lighting hours of use, as well as breakdowns of hours of use by room type as shown in. In total 355 lighting loggers were used, and all results were found to meet precision requirements. Overall daily HOU are 2.38, which corresponds to 871 annual HOU. The coefficients from the overall model and the model which adds room type are also shown below.

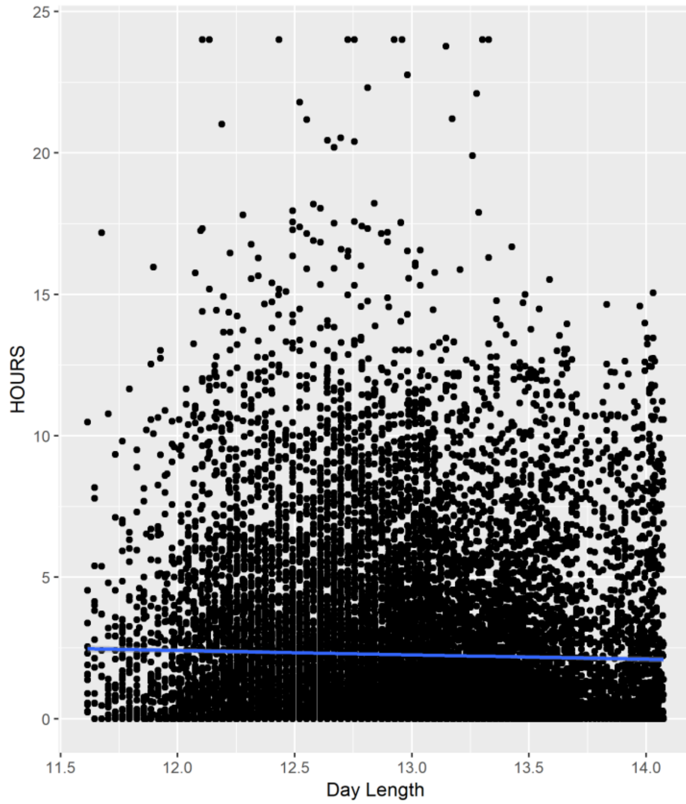
Table C-127: Hours of Use by Area

Area/Room	HOU Annual	HOU Daily	# Loggers	Precision
Kitchen	855	2.34	83	0.04
Living Room	841	2.30	81	0.04
Bedroom	796	2.18	49	0.06
Bath	1,121	3.07	62	0.04
Dining Room	769	2.11	80	0.05
Overall	**871**	**2.38**	**355**	**0.02**

Table C-128: Lighting Model Coefficients

Coefficient	Estimate	SE	T-Stat	P-value
Intercept	4.263	0.561	7.594	3.26E-14
Day Length	-0.154	0.043	-3.567	0.000362

The graph below is a scatterplot showing average hours of use for all of the loggers in the M&V sample and the corresponding day length (based on New Orleans, LA). The fitted line shows a slightly negative relationship between average daily hours and day length, which an expedited pattern ex-ante. The day length coefficients for both models also confirm this relationship, as they are both negative, although neither is statistically significant.



C.5.1.4.2. Coincidence Factor

the TPE calculated the coincident factor (CF) based on actual lighting logger data in July through September between the hours of 4 and 5 pm as 11.12%.

C.5.1.4.3. Exterior Lighting

Annual hours of operation for exterior lighting, which operates during non-daylight hours, was calculated using dusk-to-dawn data taken from the National Oceanic and Atmospheric Administration website. Savings for lamps installed in exterior areas of residences should be calculated using 4,319 hours annually, and 0% CF.

C.5.1.5. Calculation of Deemed Savings

C.5.1.5.1. Energy Savings

$$kWh_{savings} = \left(\left(W_{base} - W_{post}\right)/1000\right) \times Hours \times ISR \times IEF_E$$

Where:

W_{base} = Based on wattage equivalent of the lumen output of the purchased lamp and the program year purchased/installed (see Table C-134 and Table C-138 for LEDs, *Table C-144* and Table C-147 for CFLs)

W_{post} = Actual wattage of lamp purchased/installed

$Hours$ = Average hours of use per year (see Table *C-129*)

IEF_E = Interactive Effects Factor to account for cooling energy savings and heating energy penalties; this factor also applies to outdoor and unconditioned spaces (see Table C-131)

ISR = In Service Rate, or percentage of rebate units that get installed, to account for units purchased but not immediately installed (see *Table C-130***Error! Reference source not found.**)

When the EISA 2007 standard goes into effect for lighting, the reduced wattage savings should be claimed for the rest of the measure life.

Table C-129: Average Hours of Use Per Year

Installation Location	***Hours***
Indoor[326]	870.50
Outdoor[327]	4,319

Table C-130: In Service Rates

Delivery Channel	***ISR***
Retail (Time of Sale) and Direct Install[328]	0.98
Mailer Kit[329,330]	0.71

[326] Indoor Hours based off aggregated lighting study performed by TPE with lighting logger data from 80 homes.

[327] Calculated using dusk-to-dawn data taken from the National Oceanic and Atmospheric Administration website

[328] Dimetrosky, S. et al, 205, ,"Residential Lighting Evaluation Protocol – The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures." January. ISR for upstream programs, including storage lamps installed within four years of purchase.

[329] Based on primary data collection from 4,572 PY5-9 program participants.

[330] Applicable only to A-lamp LEDs.

Table C-131: IEF for Cooling/Heating Savings

Heating Type	Interactive Effects Factor (IEF_E)[331]
Gas Heat with AC	1.10
Gas Heat with no AC	1.00
Electric Resistance Heat with AC	0.83
Electric Resistance Heat with no AC	0.73
Heat Pump	0.96
Heating/Cooling Unknown[332]	0.91

C.5.1.5.2. Peak Demand Savings

$$kW_{savings} = \left((W_{base} - W_{post})/1000\right) \times CF \times ISR \times IEF_D$$

Where:

CF = Coincidence Factor (see Table C-132)

IEF_D = Interactive Effects Factor to account for cooling demand savings; this factor also applies to outdoor and unconditioned spaces (see Table C-133).

Table C-132: Residential Lighting Efficiency – Summer Peak Coincidence Factor

Lamp Location	CF
Indoor[333]	11.12%
Outdoor	0%

Table C-133: IEF for Cooling Demand Savings

Heating Type	Interactive Effects Factor (IEF_D)[334]
Gas Heat with AC	1.29
Gas Heat with no AC	1.00
Electric Resistance Heat with AC	1.29
Electric Resistance Heat with no AC	1.00
Heat Pump	1.29
Heating/Cooling Unknown[335]	1.21

[331] Refer to Appendix I, Arkansas TRM 6.0 Volume 3.

[332] Unknown factors are based on EnergyStar Interactive effects, weighted by primary data collected on New Orleans typical HVAC arrangements.

[333] Based off of TPE lighting metering, detailed in this chapter

[334] Refer to Appendix I, Arkansas TRM 6.0 Volume 3.

[335] Unknown factors are based on EnergyStar Interactive effects, weighted by primary data collected on New Orleans typical HVAC arrangements.

C.5.1.6. Annual kW, Annual kWh, and Lifetime kWh Savings Calculation Example

A 5W CFL is installed in program year (PY) 2016. In July 2014 Tier 1 EISA 2007 standards went into effect, and the baseline shifted to 29 watts. In January 2023, due to Tier 2 EISA 2007 standards going into effect, the baseline will shift again to 12 watts. This CFL has a rated life of 15,000 hours. Necessary inputs for calculating the kWh savings include the EUL (13.0 years), IEF_D (1.25 for unknown heating/cooling type), IEF_E (0.97 for unknown cooling/heating type), ISR (0.98), summer coincidence factor (0.1112), and Hours of Use per Year (870.50 hours). All kWh values are rounded to the second decimal place.

PY 2018 through PY 2022 Savings: From January 2018 to December 2022, the baseline is 29 watts. 2023 – 2018 is 5 years.

$$2018\ to\ 2023\ kW\ Savings\ (for\ each\ year) = \left(\frac{[29-5]}{1000}\right) \times 0.1112 \times 1.21 \times 0.98$$

$$= 0.0032\ kW$$

$$Cumulative\ 2018\ to\ 2023\ kWh\ Savings = \left(\frac{[29-5]}{1000}\right) \times 870.50 \times 0.91 \times 0.98 \times 6$$

$$= 111.79\ kWh$$

PY 2023 through PY 2028 Savings: In January 2023, the baseline changes to the 2nd Tier EISA 2007 standard. The baseline wattage changes from 29 watts to 12 watts. The remaining measure life is 5 years.

$$2023\ to\ 2028\ kW\ Savings\ (for\ each\ year) = \left(\frac{[12-5]}{1000}\right) \times 0.1112 \times 1.21 \times 0.98$$

$$= 0.0009\ kW$$

$$Cumulative\ 2023\ to\ 2028\ kWh\ Savings = \left(\frac{[12-5]}{1000}\right) \times 870.50 \times 0.91 \times 0.98 \times 5$$

$$= 27.17\ kWh$$

Lifetime kWh Savings:

$$111.79 + 27.17 = 138.96\ kWh\ lifetime\ savings$$

C.5.1.7. Cross-Sector Sales

For retail (time of sale) programs, increased savings may be claimed based on sales to nonresidential customers.[336] Based on a review of 23 utility programs across 10 states, 6.7% of installed lamps may be allocated to the commercial program. To implement, multiply the total number of fixtures by 6.7% and apply the savings methodologies

336 Dimetrosky, S., Parkinson, K. & Lieb, N. 2015, "Residential Lighting Evaluation Protocol – The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures." January.

described in the Commercial Lighting Efficiency measure. Since no building type will have been identified, apply the weighted average annual operating hours and coincidence factor based on a review of the building types that participating in commercial lighting programs during the current program year.

Calculate savings for the remaining 93.3% of fixtures using the residential savings calculations described below. If it is not possible to apply the commercial allocation strategy described above, a program may calculate savings for all fixtures using the residential savings calculations described below. This will result in a conservative estimate for upstream programs. Note: This strategy should only be applied to retail (time of sale) programs. For all other programs, use the residential savings calculations exclusively.

C.5.1.8. Future Studies

This measure is a High Impact Measure, having constituted more than 1% of residential Energy Smart program savings. However, most the major research need (hours of use and coincidence) has been completed. Given the pending code change to EISA Phase II starting in 2020, this measure should not be the focus of other research studies for future program implementation. EM&V for this measure should focus on savings validation.

The TPE recommends that this measure cease implementation when EISA Phase II takes effect in 2020, unless program administrators can show that the savings are still cost-effective under the more stringent baseline.

C.5.2. ENERGY STAR® Omni-Directional LEDs

C.5.2.1. Measure Description

This measure provides a method for calculating savings for replacing an incandescent lamp with an omni-directional LED in residential applications. The applicable lamp types that are omni-directional LEDs are the following shapes, using ANSI C79.1-2002 nomenclature: A, BT, P, PS, S, and T.[337]

C.5.2.2. Baseline

The baseline equipment is assumed to be an incandescent or halogen lamp with adjusted baseline wattages compliant with EISA 2007 regulations dictate higher efficiency baseline lamps.

The baselines for omni-directional LED lamps are summarized in Table C-134.

Table C-134: ENERGY STAR® Omni-Directional LEDs – EISA Baselines

Minimum Lumens	***Maximum Lumens***	***Incandescent Equivalent 1st Tier EISA 2007 (W_{base})***	***Incandescent Equivalent 2nd Tier EISA 2007 (W_{base})[338]***	***Effective dates for 2nd Tier EISA 2007 Baselines***
310	749	29	12	1/1/2023[339]
750	1,049	43	20	1/1/2023
1,050	1,489	53	28	1/1/2023
1,490	2,600	72	45	1/1/2023

C.5.2.3. Efficiency Standard

Omni-directional LEDs must be a standard ENERGY STAR® qualified omni-directional LED.

Exceptions to the ENERGY STAR® label are allowed for unlisted lamps, fixtures or other lighting-related devices that have been submitted to ENERGY STAR® for approval. If the lamp or fixture does not achieve ENERGY STAR® approval within the Arkansas DSM program year, however, then the lamp or fixture would have to be immediately withdrawn from the program.

C.5.2.4. Estimated Useful Life (EUL)

[337] According to ENERGY STAR®, omni-directional LED products "…shall have an even distribution of luminous intensity (candelas) within the 0° to 135° zone (vertically axially symmetrical). Luminous intensity at any angle within this zone shall not differ from the mean luminous intensity for the entire 0° to 135° zone by more than 20%. At least 5% of total flux (lumens) must be emitted in the 135°-180° zone. Distribution shall be vertically symmetrical as measured in three vertical planes at 0°, 45°, and 90°." http://www.energystar.gov/ia/partners/product_specs/program_reqs/Integral_LED_Lamps_Program_Requirements.pdf.

[338] Wattages developed using the 45 lpw standard that goes into effect in 2020.

[339] 2023 allows for a one year "sell-through" period where retailers may sell off existing less efficient stock.

The EUL is calculated as follows: Rated life in hours (15,000 hours life) / Average annual hours of use (871). The measure life for indoor and outdoor LED omni-directional lamps is 17.23 years[340]. Due to the EISA standards, the savings over the useful life will need to be adjusted to account for second tier EISA standards for all years after 2023.

Table C-135: ENERGY STAR® Omni-Directional LEDs – Measure Life

Rated Measure Life (Hours)	First Tier EISA Standard Baseline	Second Tier EISA Standard Baseline
≥ 15,000[341]	3	14

C.5.2.5. Deemed Savings Per Lamp

Table *C-136* summarizes the unit energy savings for directional LEDs in each lumen bin. This assumes retail markdown delivery and an unknown heating and cooling system configuration.

Table C-136: ENERGY STAR® Omnidirectional LEDs – Deemed Savings Per Lamp

Minimum Lumens	Maximum Lumens	Incandescent Equivalent 1st Tier EISA 2007 (W_{base})	LED Wattage	kWh/Lamp	kW/Lamp
310	749	29	7	17.08	0.00290
750	1,049	43	9	26.39	0.00448
1,050	1,489	53	12	31.83	0.00541
1,490	2,600	72	15	44.25	0.00752

C.5.2.6. Calculation of Savings

See Section. C.5.1.5 Calculation of Deemed Savings.

C.5.2.7. Incremental Cost

Prices for LEDs decrease each year. Given this, actual lighting costs should be compared to a stipulated baseline cost where feasible. If that information is not available, use costs detailed in the table below.

[340] Emerging Technologies Research Report prepared for the Regional Evaluation, Measurement, and Verification Forum facilitated by the Northeast Energy Efficiency Partnerships (NEEP). February 13, 2013.

[341] Minimum requirement from current ENERGY STAR® specification. https://www.energystar.gov/products/lighting_fans/light_bulbs/key_product_criteria.

Table C-137: ENERGY STAR® Directional LEDs Incremental Costs[342]

Year	EISA Compliant Halogen Cost	LED A-Lamp Cost	Incremental Cost
Directional	$1.25	$3.11	$1.86
Specialty		$2.70	$1.45

C.5.2.1. Net-to-Gross Ratio

The NTGR for this measure is 62%[343] for direct install applications, and 65%[344] for home energy mailer kit applications.

C.5.2.2. Future Studies

This measure is a High Impact Measure, having constituted more than 1% of residential Energy Smart program savings. However, the major research need (hours of use and coincidence) has been completed. Further, given the pending code change to EISA Phase II starting in 2020, this measure should not be the focus of research studies for future program implementation. EM&V for this measure should focus on savings validation.

The TPE recommends that this measure cease implementation when EISA Phase II takes effect in 2020, unless program administrators can show that the savings are still cost-effective under the more stringent baseline.

[342] Illinois TRM v8.0. Final draft, September 20th, 2019.

[343] Based on primary data collection from 126 PY6-9 program participants.

[344] Based on primary data collection from 221 PY9 program participants.

C.5.3. ENERGY STAR® Directional and Specialty LEDs

C.5.3.1. Measure Description

This measure provides a method for calculating savings for replacing an incandescent or halogen reflector or other specialty lamp with an ENERGY STAR® qualified LED lamp. These lamp shapes include PAR, R, BR, MR, and similar lamp shapes, as well as other specialty lamps such as 3-way lamps, globes and candelabra base lamps.

C.5.3.2. Baseline

The baseline equipment is assumed to be an incandescent or halogen lamp, and where applicable, with adjusted baseline wattages compliant with EISA 2007 regulations dictate higher efficiency baseline lamps.

Directional and most specialty lamps were not covered under Tier 1 EISA legislation. Directional lamps are currently governed by a 2009 DOE rulemaking for Incandescent Reflector Lamps (IRL)—this ruling went into effect in July 2012. The baselines for these products are from this IRL ruling in July 2012. The first Tier of EISA 2007 regulations, as originally drafted, did not apply to all bulb types. Commonly used pre-2020 EISA-exempt bulbs include: reflectors, three-way bulbs, globes with ≥ 5-in. diameter or ≤ 749 lumens, candelabra base bulbs with ≤ 1049 lumens.[345]

On January 18, 2017, DOE issued the Final Rules on General Service Lamps for the second Tier of EISA.[346] These rules, in general, expand the definition of GSLs, extending the covered lumen range, base types, and shapes, as well as reduce the types of bulbs exempted. According to the rulings, these expanded bulbs will be subject to GSL efficiency standards, including the 2020 backstop, starting January 1, 2020. This ruling covers IRLs and adds them to the provisions for EISA Tier 2.

The ruling includes the following:

- **Reflector exemptions:** Reflector bulbs will no longer be exempt. The following three reflector lamp types (which represent the vast majority of reflectors) are no longer exempt from GSL standards: (A) Lamps rated at 50 watts or less that are ER30, BR30, BR40, or ER40 lamps; (B) Lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; or (C) R20 incandescent reflector lamps rated 45 watts or less.
- **Lumen maximums:** The lumen maximum subject to the EISA GSL definition has been expanded to 3,300 lumens (previously 2600).
- **Base types exemptions**: All standard bulb bases will be included (small screw base and candelabra).

[345] See EISA legislation for the full list of exemptions.

[346] https://energy.gov/eere/buildings/downloads/two-gsl-final-rules

- **Other exemptions**: 3-way, decorative (including globes <5", flame shapes and candelabra shape), T-lamps (≤40w OR ≥ 10"), vibration service, rough service, and shatter resistant bulb exemptions are to be discontinued. These bulbs will be subject to GSL efficiency regulations starting January 1, 2020.

C.5.3.2.1. Directional

Table C-138: ENERGY STAR® Directional LEDs – Reflector Lamps Baseline Watts [347]

Lamp Type	Incandescent Equivalent (Pre-EISA)	WattsBase (Post-EISA)	WattsBase (Post-EISA)[348]
PAR20	50	35	23
PAR30	50	35	23
R20	50	45	29
PAR38	60	55	35
BR30	65	EXEMPT	38
BR40	65	EXEMPT	38
ER40	65	EXEMPT	38
BR40	75	65	42
BR30	75	65	42
PAR30	75	55	35
PAR38	75	55	35
R30	75	65	42
R40	75	65	42
PAR38	90	70	45
PAR38	120	70	45
R20	≤ 45	EXEMPT	23
BR30	≤ 50	EXEMPT	EXEMPT
BR40	≤ 50	EXEMPT	EXEMPT
ER30	≤ 50	EXEMPT	EXEMPT
ER40	≤ 50	EXEMPT	EXEMPT

C.5.3.2.2. Specialty

ENERGY STAR provides separate equivalent incandescent wattages for specialty and decorative bulb shapes. These shapes include candle, globe, bullet, and shapes other than A-lamp bulbs.[349] For these bulbs, use the $Watts_{Base}$ from Table C-139.

[347] Based on manufacturer available reflector lighting products as available in August 2013.

[348] Developed based on using Tier 1 efficacy for standard lamps and adjusting efficacy to the 45 lum/Watt requirement stated for EISA Tier 2.

[349] ANSI Shapes for decorative bulbs: B, BA, C, CA, DC, and F. Globe shapes are labeled as ANSI shape G.

Table C-139: Baseline Wattage by Lumen Output for Specialty Lamps[350]

Lumen Bins (decorative)	Lumen Bins (globe)	Incandescent Equivalent WattsBase (Exempt Bulbs)	WattsBase (Post-EISA 2007)
	1100-1300	150	72
	650-1099	100	72
	575-649	75	53
500-699	500-574	60	43
300-499	350-499	40	29
150-299	250-349	25	25
90-149		15	15
70-89		10	10

ENERGY STAR provides separate equivalent incandescent wattages for specialty and decorative bulb shapes. These shapes include candle, globe, bullet, and shapes other than A-lamp bulbs.[351] For these bulbs, use the $Watts_{Base}$ from Table C-140.

Table C-140: Baseline Wattage by Lumen Output for Specialty Lamps[352]

Lumen Bins (decorative)	Lumen Bins (globe)	Incandescent Equivalent WattsBase (Exempt Bulbs)	WattsBase (Post-EISA 2007)
	1100-1300	150	72
	650-1099	100	72
	575-649	75	53
500-699	500-574	60	43
300-499	350-499	40	29
150-299	250-349	25	25
90-149		15	15
70-89		10	10

For other specialty, EISA exempt lamps[353], use the baseline wattage in Table C-141. Commonly used EISA exempt lamps include 3-way lamps, globes with ≥ 5" diameter or

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350 Lumen bins and incandescent equivalent wattages from ENERGY STAR labeling requirements, Version 1.0 http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Lamps%20V1.0%20Final%20Draft%20Specification.pdf EISA Standards from: United States Department of Energy. Impact of EISA 2007 on General Service Incandescent Lamps: FACT SHEET.

351 ANSI Shapes for decorative bulbs: B, BA, C, CA, DC, and F. Globe shapes are labeled as ANSI shape G.

352 Lumen bins and incandescent equivalent wattages from ENERGY STAR labeling requirements, Version 1.0 http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Lamps%20V1.0%20Final%20Draft%20Specification.pdf EISA Standards from: United States Department of Energy. Impact of EISA 2007 on General Service Incandescent Lamps: FACT SHEET.

353 A complete list of the 22 incandescent lamps exempt from EISA 2007 is listed in the United States U.S. DOE Impact of EISA 2007 on General Service Incandescent Lamps: FACT SHEET.

≤ 749 lumens, and candelabra base lamps with ≤ 1049 lumens. See EISA legislation for full list of exemptions. If rated lumen values fall above or below these values, use manufacturer rated equivalent incandescent wattage.

Table C-141: ENERGY STAR® Directional LEDs –Baseline Watts for EISA-Exempt Lamps[354]

Minimum Lumens	Maximum Lumens	Incandescent Equivalent (W_{base})
310	749	40
750	1,049	60
1,050	1,489	75
1,490	2,600	100

C.5.3.3. Efficiency Standard

LEDs must be ENERGY STAR® qualified for the relevant lamp shape being removed.

Exceptions to the ENERGY STAR® label are allowed for unlisted lamps, fixtures or other lighting-related devices that have been submitted to ENERGY STAR® for approval. If the lamp or fixture does not achieve ENERGY STAR® approval within the New Orleans DSM program year, however, then the lamp or fixture would have to be immediately withdrawn from the program.

C.5.3.4. Estimated Useful Life (EUL)

The measure life for indoor and outdoor LED reflector and decorative lamps is 20 years.[355]

C.5.3.5. Deemed Savings Per Lamp

Table C-142 summarizes the unit energy savings for directional LEDs by lamp configuration. This assumes retail markdown delivery and an unknown heating and cooling system configuration.

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www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/general_service_incandescent_factsheet.pdf.

[354] Note that ENERGY STAR® has recently assigned new incandescent equivalent wattage lumen bins for the ENERGY STAR® v2.0 lighting standards (see https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Revised%20OCT-2016_1.pdf, page 13). This TRM maintains the EISA lumen bins for assigning baseline wattage. Future TRM iterations of the AR TRM, however, may incorporate these new lumen bins for baseline wattage estimates.

[355] Emerging Technologies Research Report prepared for the Regional Evaluation, Measurement, and Verification Forum facilitated by the Northeast Energy Efficiency Partnerships (NEEP). February 13, 2013.

Table C-142: Deemed Savings for ENERGY STAR® Directional LEDs

Lamp Type	Incandescent Equivalent (Pre-EISA)	Baseline Watts	Efficient Watts	kWh/Lamp	kW/Lamp
PAR20	50	35	8	20.96	0.00356
PAR30	50	35	11	18.63	0.00316
R20	50	45	8	28.72	0.00488
PAR38	60	55	11	34.16	0.00580
BR30	65	65	10	42.70	0.00725
BR40	65	65	14	39.59	0.00672
ER40	65	65	14	39.59	0.00672
BR40	75	65	14	39.59	0.00672
BR30	75	65	13	40.37	0.00686
PAR30	75	55	13	32.61	0.00554
PAR38	75	55	14	31.83	0.00541
R30	75	65	9	43.47	0.00738
R40	75	65	12	41.14	0.00699
PAR38	90	70	11	45.80	0.00778
PAR38	120	70	15	42.70	0.00725
R20	≤ 45	45	6	30.28	0.00514
BR30	≤ 50	50	9	31.83	0.00541
BR40	≤ 50	50	12	29.50	0.00501
ER30	≤ 50	50	11	30.28	0.00514
ER40	≤ 50	50	12	29.50	0.00501

C.5.3.6. Calculation of Deemed Savings

Deemed savings are calculated in the same manner as for standard CFLs (see Section C.5.5.6).

C.5.3.7. Incremental Cost

Prices for LEDs decrease each year. Given this, actual lighting costs should be compared to a stipulated baseline cost where feasible. If that information is not available, use costs detailed in the table below

Table C-143: ENERGY STAR® Directional LEDs Incremental Costs from 2019 Forward[356]

Type	Incandescent Cost	LED Cost	Incremental Cost
Directional	$3.53	$5.18	$1.65
Specialty	$1.74	$3.40	$1.66

[356] Illinois TRM v8.0. Final draft, September 20th, 2019.

C.5.3.8. Future Studies

This measure is a High Impact Measure, having constituted more than 1% of residential Energy Smart program savings. Further, given the pending code change to EISA Phase II starting in 2020, this measure should not be the focus of research studies for future program implementation. EM&V for this measure should focus on savings validation.

The TPE recommends that this measure cease implementation when EISA Phase II takes effect in 2020, unless program administrators can show that the savings are still cost-effective under the more stringent baseline.

The TPE recommends that this measure cease implementation when EISA Phase II takes effect in 2020, unless program administrators can show that the savings are still cost-effective under the more stringent baseline.

C.5.4. ENERGY STAR® Omni-Directional Compact Fluorescent Lamps (CFLs)

C.5.4.1. Measure Description

This measure provides a method for calculating savings for replacing an incandescent lamp with a standard CFL in residential applications.

C.5.4.2. Baseline

The baseline equipment is assumed to be an incandescent or halogen lamp with adjusted baseline wattages compliant with EISA 2007 regulations dictate higher efficiency baseline lamps.

When the EISA 2007 standard goes into effect for a CFL, the reduced wattage savings should be claimed for the rest of the measure life. For example, up until 2022, a 20W CFL with 1200 lumens may claim a 53W baseline. After 2022, the baseline becomes 27W for the remainder of the measure life.

Table C-144: ENERGY STAR® CFLs – EISA Baselines[357]

Minimum Lumens	*Maximum Lumens*	*Incandescent Equivalent 1st Tier EISA 2007 (W_{base})*	*Incand. Equiv. 2nd Tier EISA 2007 (W_{base})*[358]	*Effective dates for 2nd Tier EISA 2007 Baselines*
310	749	29	12	1/1/2023[359]
750	1,049	43	20	1/1/2023
1,050	1,489	53	28	1/1/2023
1,490	2,600	72	45	1/1/2023

C.5.4.3. Efficiency Standard

CFLs must be a standard ENERGY STAR® qualified CFL.

Exceptions to the ENERGY STAR® label are allowed for unlisted lamps, fixtures or other lighting-related devices that have been submitted to ENERGY STAR® for approval. If the lamp or fixture does not achieve ENERGY STAR® approval within the New Orleans program year, however, then the lamp or fixture would have to be immediately withdrawn from the program.

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[357] Note that ENERGY STAR® has assigned new incandescent equivalent wattage lumen bins for the upcoming ENERGY STAR® lighting standards, coming into effect September 2014. Due to the likelihood of sell-through of existing ENERGY STAR® lighting through fall 2014 and the on-going use of the EISA bin definitions, this TRM maintains the EISA lumen bins for assigning baseline wattage. Future TRM iterations of the New Orleans TRM, however, may incorporate these new lumen bins for baseline wattage estimates.

[358] Wattages developed using the 45 lpw standard that goes into effect in 2020.

[359] 2023 allows for a one year “sell-through” period where retailers may sell off existing less efficient stock.

C.5.4.4. Estimated Useful Life (EUL)

The average measure life is based upon rated lamp life of the CFL shown in the following table. The measure life assumes an average daily use of 2.38 blended[360] hours for indoor/outdoor applications and applies a 0.688[361] degradation factor to indoor residential CFLs. This table shows the useful life that should be used for the first tier EISA baseline, and the useful life remaining for the increased second tier EISA standard baseline.

Note that the values are in this table are incremented each program year so that the first-tier values do not exceed 2023 minus the program year. For PY10 (calendar year 2020), the first-tier measure life cannot exceed the result of 2023 - 2020, which is equal to 3 years. The remainder of the measure life is applied to the second tier.

Table C-145: ENERGY STAR® CFLs – Measure Life[362]

Rated Measure Life (Hours)	***First Tier EISA Standard Baseline***		***Second Tier EISA Standard Baseline***	
	CFL Indoor Application – Measure Life (Years)	***CFL Outdoor Application – Measure Life (Years)***	***CFL Indoor Application – Measure Life (Years)***	***CFL Outdoor Application – Measure Life (Years)***
8,000	3	3	4	4
10,000	3	3	6	6
12,000	3	3	7	8
15,000	3	3	10	10

C.5.4.5. Deemed Savings Per Lamp

Table *C-146* summarizes the unit energy savings for general service lamps in each lumen bin. This assumes retail markdown delivery and an unknown heating and cooling system configuration.

[360] TPE lighting metering, detailed in this chapter.

[361] Average of 0.526 and 0.85. Original 0.526 is from Itron, Hirsch and Associates, and Research Into Action, "Welcome to the Dark Side: The Effect of Switching on CFL Measure Life"2008 ACEEE Summer Study on Energy Efficiency in Buildings, p. 2-146; and 0.85 is from ENERGY STAR® CFL THIRD PARTY TESTING AND VERIFICATION Off-the-Shelf CFL Performance: Batch 3. Figure 27, p. 47.

[362] EUL = Rated Measure Life in Hours * Degradation Factor / (365.25 * Average Hours of Daily Use). Degradation Factor = 0.526 for indoor applications and 1.000 for outdoor applications.

Table C-146: ENERGY STAR® CFLs – Deemed Savings Per Lamp

Minimum Lumens	Maximum Lumens	Incandescent Equivalent 1st Tier EISA 2007 (W_{base})	CFL Wattage	kWh/Lamp	kW/Lamp
310	749	29	10	14.75	0.00251
750	1,049	43	14	22.51	0.00382
1,050	1,489	53	20	25.62	0.00435
1,490	2,600	72	26	35.71	0.00607

C.5.4.6. Calculation of Deemed Savings

See section C.5.1.5 Calculation of Deemed Savings.

C.5.4.7. Incremental Cost

Costs by delivery channel area as follows:

- Retail Markdown: $1.20[363]
- Direct Install: program actual. If unavailable, use full measure cost of $2.45 per bulb plus $5 installation cost[364].
- Efficiency Kits: program actual.

C.5.4.8. Future Studies

This measure is a High Impact Measure, having constituted more than 1% of residential Energy Smart program savings. However, most the major research need (hours of use and coincidence) has been completed. Given the pending code change to EISA Phase II starting in 2020, this measure should not be the focus of other research studies for future program implementation. EM&V for this measure should focus on savings validation.

The TPE recommends that this measure cease implementation when EISA Phase II takes effect in 2020, unless program administrators can show that the savings are still cost-effective under the more stringent baseline.

[363] Illinois TRM v6.0. Final draft, February 8th, 2017.

[364] Assumes 15 minutes at $20/hour. This includes proration of travel time to the site.

C.5.5. ENERGY STAR® Specialty Compact Fluorescent Lamps (CFLs)

C.5.5.1. Measure Description

This measure provides a method for calculating savings for replacing a specialty incandescent or halogen lamp with an ENERGY STAR®-qualified specialty CFL. These lamps include R, PAR, ER, BR, BPAR, globes G40, decorative globes equal to or less that 60W with candelabra base, and decorative candles equal to or less than 60W with candelabra base.

C.5.5.2. Baseline

The baseline equipment is a specialty incandescent or halogen lamp.[365]

C.5.5.2.1. Reflector

The baseline wattages for reflector lamps are presented in Table C-147.

Table C-147: ENERGY STAR® Specialty CFLs - Baseline Watts for Reflector Lamps[366]

Lamp Type	*Incandescent Equivalent (Pre-EISA)*	*WattsBase (Post-EISA)*	*WattsBase (Post-EISA)*[367]
PAR20	50	35	23
PAR30	50	35	23
R20	50	45	29
PAR38	60	55	35
BR30	65	EXEMPT	38
BR40	65	EXEMPT	38
ER40	65	EXEMPT	38
BR40	75	65	42
BR30	75	65	42
PAR30	75	55	35
PAR38	75	55	35
R30	75	65	42
R40	75	65	42
PAR38	90	70	45
PAR38	120	70	45
R20	≤ 45	EXEMPT	23
BR30	≤ 50	EXEMPT	EXEMPT
BR40	≤ 50	EXEMPT	EXEMPT

[365] Note that on January 18, 2017, DOE issued the Final Rules on General Service Lamps for the second Tier of EISA (https://energy.gov/eere/buildings/downloads/two-gsl-final-rules). These rules, in general, expand the definition of GSLs, extending the covered lumen range, base types, and shapes, as well as reduce the types of bulbs exempted. According to the rulings, these expanded bulbs will be subject to GSL efficiency standards, including the 2020 backstop, starting January 1, 2020.

[366]Based on manufacturer available reflector lighting products as available in August 2013.

[367] Developed based on using Tier 1 efficacy for standard lamps and adjusting efficacy to the 45 lum/Watt requirement stated for EISA Tier 2.

Lamp Type	*Incandescent Equivalent (Pre-EISA)*	*WattsBase (Post-EISA)*	*WattsBase (Post-EISA)*[367]
ER30	≤ 50	EXEMPT	EXEMPT
ER40	≤ 50	EXEMPT	EXEMPT

C.5.5.2.2. Specialty

ENERGY STAR provides separate equivalent incandescent wattages for specialty and decorative bulb shapes. These shapes include candle, globe, bullet, and shapes other than A-lamp bulbs.[368] For these bulbs, use the $Watts_{Base}$ from Table C-148.

Table C-148: Baseline Wattage by Lumen Output for Specialty Lamps[369]

Lumen Bins (decorative)	*Lumen Bins (globe)*	*Incandescent Equivalent WattsBase (Exempt Bulbs)*	*WattsBase (Post-EISA 2007)*
	1100-1300	150	72
	650-1099	100	72
	575-649	75	53
500-699	500-574	60	43
300-499	350-499	40	29
150-299	250-349	25	25
90-149		15	15
70-89		10	10

For other specialty, EISA exempt lamps[370], use the baseline wattage in

[368] ANSI Shapes for decorative bulbs: B, BA, C, CA, DC, and F. Globe shapes are labeled as ANSI shape G.

[369] Lumen bins and incandescent equivalent wattages from ENERGY STAR labeling requirements, Version 1.0 http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Lamps%20V1.0%20Final%20Draft%20Specification.pdf EISA Standards from: United States Department of Energy. Impact of EISA 2007 on General Service Incandescent Lamps: FACT SHEET.

[371]Note that ENERGY STAR® has recently assigned new incandescent equivalent wattage lumen bins for the ENERGY STAR® v2.0 lighting standards (see https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Revised%20OCT-2016_1.pdf, page 13)). this TRM maintains the EISA lumen bins for assigning baseline wattage. Future TRM iterations of the TRM, however, may incorporate these new lumen bins for baseline wattage estimates.

Table C-149. Commonly used EISA exempt lamps include 3-way lamps, globes with ≥ 5" diameter or ≤ 749 lumens, and candelabra base lamps with ≤ 1049 lumens. See EISA legislation for full list of exemptions. If rated lumen values fall above or below these values, use manufacturer rated equivalent incandescent wattage.

Table C-149: Baseline Wattage for Specialty, EISA Exempt Lamps[371]

Minimum Lumens	Maximum Lumens	Incandescent Equivalent (Wbase)
310	749	40
750	1,049	60
1,050	1,489	75
1,490	2,600	100

C.5.5.3. Efficiency Standard

CFLs must be an ENERGY STAR® specialty CFL.

Exceptions to the ENERGY STAR® label are allowed for unlisted lamps, fixtures or other lighting-related devices that have been submitted to ENERGY STAR® for approval. If the lamp or fixture does not achieve ENERGY STAR® approval within the program year, however, then the lamp or fixture would have to be immediately withdrawn from the program.

C.5.5.4. Estimated Useful Life (EUL)

The average measure life is based upon rated lamp life of the CFL shown in the following table. The measure life assumes an average daily use of 270.50 blended hours for indoor/outdoor applications and applies a 0.688[372] degradation factor to indoor residential CFLs.

Table C-150: ENERGY STAR® Specialty CFLs – Measure Life[373]

Rated Measure Life (Hours)	Measure Life (Years)
8,000	7
10,000	9
12,000	10
15,000	13

[371] Note that ENERGY STAR® has recently assigned new incandescent equivalent wattage lumen bins for the ENERGY STAR® v2.0 lighting standards (see https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Revised%20OCT-2016_1.pdf, page 13)). this TRM maintains the EISA lumen bins for assigning baseline wattage. Future TRM iterations of the TRM, however, may incorporate these new lumen bins for baseline wattage estimates.

[372] Average of 0.526 and 0.85. Original 0.526 is from Itron, Hirsch and Associates, and Research Into Action, "Welcome to the Dark Side: The Effect of Switching on CFL Measure Life". 2008 ACEEE Summer Study on Energy Efficiency in Buildings, p. 2-146; and 0.85 is from ENERGY STAR® CFL THIRD PARTY TESTING AND VERIFICATION Off-the-Shelf CFL Performance: Batch 3. Figure 27, p. 47.

[373] EUL = Rated Measure Life in Hours * Degradation Factor / (365.25 * Average Hours of Daily Use). Degradation Factor = 0.526 for indoor applications and 1.000 for outdoor applications.

C.5.5.5. Deemed Savings Per Lamp

Table *C-151* summarizes the unit energy savings for specialty CFLs in each lumen bin. This assumes retail markdown delivery and an unknown HVAC system configuration.

Table C-151: ENERGY STAR® Specialty CFLs – Deemed Savings Per Lamp

Minimum Lumens	*Maximum Lumens*	*Incandescent Equivalent 1st Tier EISA 2007 (W_{base})*	*CFL Wattage*	*kWh/Lamp*	*kW/Lamp*
310	749	40	10	23.29	0.00396
750	1,049	60	14	35.71	0.00607
1,050	1,489	75	20	42.70	0.00725
1,490	2,600	100	26	57.45	0.00976

C.5.5.6. Calculation of Deemed Savings

Deemed savings are calculated in the same manner as for standard CFLs (see Section C.5.5.6).

C.5.5.7. Incremental Cost

Costs by delivery channel area as follows:

- Retail Markdown: $5.00[374]
- Direct Install: program actual. If unavailable, use full measure cost of $8.50 per bulb plus $5 installation cost[375]
- Efficiency Kits: program actual

C.5.5.8. Future Studies

This measure is a High Impact Measure, having constituted more than 1% of residential Energy Smart program savings. However, the major research need (hours of use and coincidence) has been completed. Further, given the pending code change to EISA Phase II starting in 2020, this measure should not be the focus of research studies for future program implementation. EM&V for this measure should focus on savings validation.

The TPE recommends that this measure cease implementation when EISA Phase II takes effect in 2020, unless program administrators can show that the savings are still cost-effective under the more stringent baseline.

[374] NEEP Residential Lighting Survey, 2011 .

[375] Assumes 15 minutes at $20/hour. This includes proration of travel time to the site.

D.Commercial Measures

D.1. Commercial Motors

D.1.1. Electronically Commutated Motors for Refrigeration and HVAC Applications

D.1.1.1. Measure Description

An electronically commutated motor (ECM) is a fractional horsepower direct current (DC) motor used most often in commercial refrigeration applications such as display cases, walk-in coolers/freezers, refrigerated vending machines, and bottle coolers. ECMs can also be used in HVAC applications, primarily as small fan motors for packaged terminal units or in terminal air boxes. ECMs generally replace shaded pole (SP) or permanent split-capacitor (PSC) motors and offer energy savings of at least 50 percent.

D.1.1.2. Baseline and Efficiency Standards

The standard motor type for this application is a shaded pole or permanent split-capacitor motor.

Any ECM up to 1 HP in size will meet the minimum requirements for both retrofit and new construction installations.

D.1.1.3. Estimated Useful Life (EUL)

In accordance with DEER 2014, the estimated useful life (EUL) is 15 years.

D.1.1.4. Deemed Savings Values

Table D-1 summarizes deemed kWh and kW by facility type for this measure. The following assumptions are used:

- Baseline watts: 102. This is the average of SP motors (132W) and PSC motors (72W).
- Hours:
  - HVAC: 4,386
  - Refrigeration: 8,760
  - Unknown: 6,573
- COP:
  - HVAC: 3.45 (assumes 11.8 EER)
  - Refrigeration: 1.90 (average of refrigerator and freezer)
  - Unknown: 2.67
- Duty Cycle:
  - HVAC, medium-temp refrigeration: 1.00
  - Freezer: .94

- Unknown: .985

Table D-1: Deemed Savings by Facility Type

End-Use	HVAC		Refrigeration (Med. temps)		Refrigeration (Freezers)		Unknown	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Assembly	351	0.066	829	0.095	779	0.089	552	0.07
College	351	0.066	829	0.095	779	0.089	552	0.069
Fast Food	351	0.067	829	0.095	779	0.089	552	0.071
Full Menu	351	0.062	829	0.095	779	0.089	552	0.066
Grocery	351	0.068	829	0.095	779	0.089	552	0.071
Health Clinic	351	0.072	829	0.095	779	0.089	552	0.076
Large Office	351	0.068	829	0.095	779	0.089	552	0.071
Lodging	351	0.067	829	0.095	779	0.089	552	0.071
Religious Worship	351	0.062	829	0.095	779	0.089	552	0.065
Retail	351	0.066	829	0.095	779	0.089	552	0.069
Unknown	351	0.07	829	0.095	779	0.089	552	0.074

D.1.1.5. Calculation of Deemed Savings

D.1.1.5.1. Energy Savings

$$kWh_{savings} = (W_{base} - W_{ECM}) \times Hrs \times DC \times (1 + \frac{1}{COP})/1000\,{}^{W}/_{kW}$$

Where:

kW_{base} = Power of the motor being replaced; use known wattage of motor, or if unknown, use 132W (SP motors)[376] or 72W (PSC motors)[377]

kW_{ECM} = Power of the replacement EC motor; use known wattage of motor, or if unknown, use 40W[378]

The motor's power for either Base or ECM can be calculated using the following equation if power is not known. The values for rated wattage and phase can be found on motor's nameplate:

$$kW_{motor} = \frac{Volts\ \times Amperage}{1000} \times \sqrt{Phase} \times Power\ Factor$$

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[376] http://www.fishnick.com/publications/appliancereports/refrigeration/GE_ECM_revised.pdf

[377] The Massachusetts TRM specifies a load factor of 54% for SP motors and a load factor of 29% for PSC motors, as specified by National Resource Management (NRM). Multiplying the 132 W default value for SP motors by the ratio of PSC load factor to SP load factor results in a default PSC motor wattage of 72 watts.

[378] http://www.fishnick.com/publications/appliancereports/refrigeration/GE_ECM_revised.pdf

Hrs = Hours of yearly operation, use 8,760 hours for refrigeration and 4,386 for HVAC

DC = Duty cycle, only use a value of 0.94 if the application of the motor being replaced is for a freezer system. This is because the freezer will complete four 20-min defrost cycles per day where the evaporator fan will not be used. Use a value of 1 if the application is for a cooler refrigeration or HVAC.

$PowerFactor$ = Power factor of the motor, if not known an average value of 0.55 can be used for ECM in refrigeration, 0.7 for ECM in HVAC, and 0.85 for base motor in both applications.[379]

COP = Coefficient of Performance for the motor's operation based on application. COP value depends on the end temperature of the refrigeration process. The COP values to use for refrigeration analysis are 1.3 for freezers and 2.5 for coolers[380]. For HVAC, use the EER value from install spec sheet and the conversion COP = EER/3.412.

D.1.1.5.2. Demand Savings

$$kW_{HVAC\,reduction} = (kW_{base} - kW_{ECM}) \times CF \times (1 + \frac{1}{COP})$$

$$kW_{Refrigeration\,reduction} = (kW_{base} - kW_{ECM}) \times DC \times CF \times (1 + \frac{1}{COP})$$

Where:

CF = Coincidence Factor, use values from Table D-2 for HVAC applications; default value of 1.0 for refrigeration applications[381]

DC = Duty cycle, only use a value of 0.94 if the application of the motor being replaced is for a freezer refrigeration. This is because the freezer will complete four 20-min defrost cycles per day where the evaporator fan will not be used. Use a value of 1 if the application is for a cooler refrigeration of HVAC.

[379] http://www.ecw.org/sites/default/files/230-1.pdf

[380] PSC of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, pp. 4-103 -4-106.

[381] CF set to 1.0 for refrigeration applications based on annual run-time assumption of 8,760 hours

Table D-2: Commercial Coincidence Factors by Building Type[382]

Building Type	***Coincidence Factor***
Assembly	0.82
College	0.84
Fast Food	0.78
Full Menu	0.85
Grocery	0.90
Health Clinic	0.85
Large Office	0.84
Lodging	0.77
Religious Worship	0.82
Retail	0.88
School	0.71
Small Office	0.84

D.1.1.6. Incremental Cost

Incremental cost by end-use type is $177.[383]

D.1.1.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans business and updates for applicable codes.

[382] Values for Assembly and Religious Worship building types developed using an adjustment factor derived through a comparison of average CFs for College/University and Assembly/Religious Worship building types from the Texas state Technical Reference Manual. College/University was selected as a reference building type due to average alignment with Assembly/Religious worship building types in other TRMs, inclusion of a summer session, and increased evening usage.

[383] Difference in the fully installed cost ($468) for ECM motor and controller, listed in Work Paper PGE3PREF126, "ECM for Walk-In Evaporator with Fan Controller," June 20,2012, and the measure cost specified in 4.6.6 ($291)

D.1.2. Premium Efficiency Motors

D.1.2.1. Measure Description

Currently a wide variety of NEMA premium efficiency motors from 1-500 HP are available. Deemed values for demand and energy savings associated with this measure must be for motors with an equivalent operating period (hours x Load Factor) over 1,000 hours.

D.1.2.2. Baseline and Efficiency Standards

D.1.2.2.1. Replace on Burnout

The EISA 2007 Sec 313 adopted the new federal standard and required that electric motors that are manufactured and sold in the United States meet the new standard by December 19, 2010. The standards can also be found in sections 431.25(c)-(f) of the Code of Federal Regulations (10 CFR Part 431).

With these changes, any 1-500 HP motor bearing the “NEMA Premium" trademark will align with national energy efficiency standards and legislation. The Federal Energy Management Program (FEMP) has already adopted NEMA MG 1-2006 Revision 1 2007 in its Designated Product List for federal customers.

In addition to the new standards for 200-500 HP motors, additional motors in the 1-200 HP range are now included in the NEMA Premium standard. These new motors are referred to as “General Purpose Electric Motors (Subtype II)”. These additional types of motors include:

- U-Frame Motors
- Design C Motors
- Close-coupled pump motors
- Footless motors
- Vertical solid shaft normal thrust (tested in a horizontal configuration)
- 8-pole motors
- All poly-phase motors with voltages up to 600 volts other than 230/460 volts (230/460-volt motors are covered by EPAct-92)

D.1.2.2.2. Early Retirement

The baseline for early retirement projects is the nameplate efficiency of the existing motor to be replaced, if known. If the nameplate is illegible and the in-situ efficiency cannot be determined, then the baseline should be based on the minimum efficiency allowed under the Federal Energy Policy Act of 1992 (EPAct), as listed in Table D-4.

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NEMA Premium Efficiency motor levels continue to be industry standard for minimum-efficiency levels. The savings calculations assume that the minimum motor efficiency for both replace on burnout and early retirement projects exceeds that listed in Table ***D-3***.

For early retirement, the maximum age of an eligible piece of equipment is capped at the point at which it is expected that 75 percent of the equipment has failed. Where the age of the unit exceeds the 75 percent failure age, ROB savings should be applied. This cap prevents early retirement savings from being applied to projects where the age of the equipment greatly exceeds the estimated useful life of the measure.

Table D-3: Premium Efficiency Motors – Replace on Burnout Baseline[384]

hp	$n_{baseline, Open Motors}$			$n_{baseline, Closed Motors}$		
	6-Pole	4-Pole	2-Pole	6-Pole	4-Pole	2-Pole
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	87.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	94.1
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4
250	94.5	95.4	94.5	95.0	95.0	95.4
300	94.5	95.4	95.0	95.0	95.4	95.4
350	94.5	95.4	95.0	95.0	95.4	95.4
400	n/a	95.4	95.4	n/a	95.4	95.4
450	n/a	95.8	95.8	n/a	95.4	95.4
500	n/a	95.8	95.8	n/a	95.8	95.4

[384] Federal Standards for Electric Motors, Table 1: Full Load Efficiencies for Standard Electric Motors, http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/50. Accessed June 2013.

Table D-4: Premium Efficiency Motors – Early Retirement Baseline[385]

hp	$n_{baseline, Open Motors}$			$n_{baseline, Closed Motors}$		
	6-Pole	**4-Pole**	**2-Pole**	**6-Pole**	**4-Pole**	**2-Pole**
1	80.0	82.5	75.5	80.0	82.5	75.5
1.5	84.0	84.0	82.5	85.5	84.0	82.5
2	85.5	84.0	84.0	86.5	84.0	84.0
3	86.5	86.5	84.0	87.5	87.5	85.5
5	87.5	87.5	85.5	87.5	87.5	87.5
7.5	88.5	88.5	87.5	89.5	89.5	88.5
10	90.2	89.5	88.5	89.5	89.5	89.5
15	90.2	91.0	89.5	90.2	91.0	90.2
20	91.0	91.0	90.2	90.2	91.0	90.2
25	91.7	91.7	91.0	91.7	92.4	91.0
30	92.4	92.4	91.0	91.7	92.4	91.0
40	93.0	93.0	91.7	93.0	93.0	91.7
50	93.0	93.0	92.4	93.0	93.0	92.4
60	93.6	93.6	93.0	93.6	93.6	93.0
75	93.6	94.1	93.0	93.6	94.1	93.0
100	94.1	94.1	93.0	94.1	94.5	93.6
125	94.1	94.5	93.6	94.1	94.5	94.5
150	94.5	95.0	93.6	95.0	95.0	94.5
200	94.5	95.0	94.5	95.0	95.0	95.0
250	94.5	95.4	94.5	95.0	95.0	95.4
300	94.5	95.4	95.0	95.0	95.4	95.4
350	94.5	95.4	95.0	95.0	95.4	95.4
400	n/a	95.4	95.4	n/a	95.4	95.4
450	n/a	95.8	95.8	n/a	95.4	95.4
500	n/a	95.8	95.8	n/a	95.8	95.4

D.1.2.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life (EUL) is 15 years.

D.1.2.4. Calculation of Deemed Savings

Actual motor operating hours are expected to be used to calculate savings. Every effort should be made to capture the estimated operating hours. Short and/or long-term metering can be used to verify estimates. If metering is not possible, interviews with facility operators and review of operations logs should be conducted to obtain an estimate of actual operating hours. If there is not sufficient information to accurately estimate operating hours, then the annual operating hours in Table ***D-5*** or Table ***D-9***.

[385] Federal Standards for Electric Motor Efficiency from the Federal Energy Policy Act of 1992 (EPACT). http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/e-pact92.pdf . Accessed June 2013.

Table D-5: Premium Efficiency Motors – Operating Hours, Load Factor (HVAC)

Building Type	Load Factor[386]	HVAC Fan Hours[387]
College/ University	0.75	4,581
Fast Food Restaurant		6,702
Full Menu Restaurant		5,246
Grocery Store		6,389
Health Clinic		7,243
Lodging		4,067
Large Office (>30k SqFt)		4,414
Small Office (≤30k SqFt)		3,998
Retail		5,538
School		4,165

Table D-6: Premium Efficiency Motors – Operating Hours, Load Factor (Non-HVAC)

Industrial Processing	Load Factor[388]	Hours[389]					
		Chem	Paper	Metals	Petroleum Refinery	Food Production	Other
1-5 hp	0.54	4,082	3,997	4,377	1,582	3,829	2,283
6-20 hp	0.51	4,910	4,634	4,140	1,944	3,949	3,043
21-50 hp	0.60	4,873	5,481	4,854	3,025	4,927	3,530
51-100 hp	0.54	5,853	6,741	6,698	3,763	5,524	4,732
101-200 hp	0.75	5,868	6,669	7,362	4,170	5,055	4,174
201-500 hp	0.58	5,474	6,975	7,114	5,311	3,711	5,396
501-1,000 hp		7,495	7,255	7,750	5,934	5,260	8,157
>1,000 hp		7,693	8,294	7,198	6,859	6,240	2,601

386 Itron 2004-2005 DEER Update Study, Dec 2005; Table 3-25. Accessed May 2013.http://www.deeresources.com/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf .

387 Fan schedule operating hours taken as the average of operating hours from the Connecticut, Maine, and Pennsylvania Technical Reference Manuals: CL&P and UI Program Savings Documentation for 2008 Program Year, Connecticut Lighting & Power Company; Efficiency Maine Technical Reference User Manual No. 2007-1; Pennsylvania Utility Commission Technical Reference Manual June 2012.

388 United States Industrial Electric Motor Systems Market Opportunities Assessment, Dec 2002; Table 1-19. Accessed May 2013. www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mTRMkt.pdf

389 United States Industrial Electric Motor Systems Market Opportunities Assessment, Dec 2002; Table 1-15. Accessed May 2013. www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mTRMkt.pdf

D.1.2.4.1. Measure/Technology Review

Premium efficiency motors are a mature technology and a wealth of information exists on the measure. A summary of the key resources is included in Table D-7.

Table D-7: Premium Efficiency Motors- Review of Motor Measure Information

Resource	Notes
PG&E 2006[390]	Savings for common motor retrofits
Xcel Energy 2006[391]	Program level savings estimates for high-efficiency motors
DEER 2014[392]	Savings and cost for common motor retrofit
KEMA 2010[393]	Motor savings included in comprehensive potential study
CEE[394]	Industrial motor efficiency initiative
RTF[395]	Savings for common motor retrofit
ITP[396]	Savings for common motor retrofit
NPCC 2010[397]	Market information and overview of savings potential
NEMA 2009[398]	Minimum efficiency level for premium efficiency motors
MotorMaster+[399]	Comprehensive resource of motor efficiencies and tools to calculate savings
PacifiCorp 2009[400]	Motor savings included in comprehensive potential study

Deemed electric motor demand and energy savings should be calculated by the following formulas:

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[390] Pacific Gas & Electric (PG&E). 2006. *2006 Motors Unit Savings Workpapers.V14.*

[391] Xcel Energy. 2006. 2007/2008/2009 *Triennial Plan Minnesota Natural Gas and Electric Conversation Improvement Program.*

[392] Consortium of Energy Efficiency. Commercial Lighting Program. http://library.cee1.org/content/commercial-lighting-qualifying-products-lists

[393] KEMA. 2010. *Measurement Manual*. Prepared for Tennessee Valley Authority.

[394] Consortium for Energy Efficiency. 2010. Industrial Motors & Motor Systems. http://library.cee1.org/content/cee-2012-summary-member-programs-motors-motor-systems

[395] Regional Technical Forum (RTF). http://rtf.nwcouncil.org/measures/

[396] Industrial Technologies Program http://www1.eere.energy.gov/industry/

[397] Northwest Power and Conservation Council (NPCC). 2010. *The Sixth Northwest Electric Power and Conservation Plan.*

[398] National Electrical Manufacturers Association (NEMA). 2009. *Motors and Generators. NEMA* MG 1-2009.

[399] MotorMaster+. 2010. https://www1.eere.energy.gov/manufacturing/tech_assistance/software_motormaster.html

[400] PacifiCorp. 2009. *FinAnswer Express Market Characterization and Program Enhancements Utah Service Territory.*

D.1.2.4.2. Replace on Burnout (ROB)

$$kWh_{savings} = Rated\ Horsepower \times Conversion\ Factor \times LF \times \left(\frac{1}{\eta_{baseline}} - \frac{1}{\eta_{post}}\right) \times hours$$

$$kW_{reduction} = Rated\ Horsepower \times Conversion\ Factor \times LF \times \left(\frac{1}{\eta_{baseline}} - \frac{1}{\eta_{post}}\right) \times CF$$

Where:

> $Rated\ HorsePower$ = Nameplate horsepower data of the motor
>
> $Conversion\ Factor$ = 0.746 kW/hp
>
> *LF* = Estimated load factor for the motor; if load factor is not available, deemed load factors in Table ***D-5*** or Table ***D-9*** can be used.
>
> $\eta_{baseline}$= Efficiencies listed in Table ***D-3*** should be used (in the case of rewound motors, in situ efficiency may be reduced by a percentage as found in Table ***D-9***)
>
> η_{post}= Efficiency of the newly installed motor
>
> *Hours*= Estimated annual operating hours for the motor; if unavailable, annual operating hours in Table ***D-5*** or Table ***D-9*** be used.
>
> CF = Coincidence Factor = 0.74[401]

D.1.2.4.3. Early Retirement (ER)

Annual kWh and kW savings must be calculated separately for two time periods:

1. The estimated remaining life (RUL, see Table ***D-8***) of the equipment that is being removed, designated the first N years, and
2. Years EUL - N through EUL, where EUL is 15 years.

[401] Itron 2004-2005 DEER Update Study, Dec 2005; Table 3-25. http://www.deeresources.com/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf Accessed May 2013.

Table D-8: Premium Efficiency Motors – Remaining Useful Life (RUL) of Replaced Systems[402,403]

Age of Replaced System (Years)	RUL (Years)
5	10.0
6	9.1
7	8.2
8	7.3
9	6.5
10	5.7
11	5.0
12	4.4
13	3.8
14	3.3
15	2.8
16	2.5
17	2.2
18	1.9
19	0.0

For the first N years:

$$kWh_{savings} = Rated\ Horsepower\ \times Conversion\ Factor\ \times LF\ \times \left(\frac{1}{\eta_{baseline}} - \frac{1}{\eta_{post}}\right) \times hours$$

$$kW_{reduction} = Rated\ Horsepower\ \times Conversion\ Factor\ \times LF\ \times \left(\frac{1}{\eta_{baseline}} - \frac{1}{\eta_{post}}\right) \times CF$$

Where:

$Rated\ HorsePower$ = Nameplate horsepower data of the motor

$Conversion\ Factor$ = 0.746 kW/hp

LF = Estimated load factor for the motor; if load factor is not available, deemed load factors in Table ***D-5*** can be used

[402] Because the motor EUL is 15 years, it is consistent for use with the RUL determined using the Weibull distribution offered in the DOE's Life Cycle Cost Analysis Spreadsheet, "lcc_cuac_hourly.xls".

http://www1.eere.energy.gov/buildings/appliance_standards/standards_test_procedures.html.

[403] Use of the early retirement baseline is capped at 18 years, representing the age at which 75 percent of existing equipment is expected to have failed. Systems older than 18 years should use the ROB baseline.

$\eta_{baseline}$= In situ efficiency of the baseline motor; if unavailable, efficiencies listed in Table D-4 can be used (in the case of rewound motors, in situ efficiency may be reduced by a percentage as found in Table ***D-9***).

η_{post}=Efficiency of the newly installed motor

Hours= Estimated annual operating hours for the motor; if unavailable, annual operational hours in Table ***D-5*** can be used

CF = Coincidence Factor = 0.74[404]

Table D-9: Rewound Motor Efficiency Reduction Factors[405]

Motor Horsepower	***Efficiency Reduction Factor***
<40	0.01
≥40	0.005

For Years EUL - N through EUL:

Savings should be calculated exactly as they are for replace on burnout projects, referred to as $kWh_{SavingsROB}$.

Total lifetime savings for early retirement projects are then determined by adding the savings calculated under the two preceding equations as follows:

$$Lifetime\ kWh\ savings\ for\ Early\ Retirement\ Projects = \left(kWh_{savingsRUL} \times RUL\right) + \left[kWh_{savingsROB} \times (EUL - RUL)\right]$$

Where:

RUL= The Remaining Useful Life of the equipment, in years, see Table ***D-8***.

EUL = The Estimated Useful Life of the equipment, deemed at 15 years

[404] Itron 2004-2005 DEER Update Study, Dec 2005; Table 3-25. http://www.deeresources.com/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf. Accessed May 2013.

[405] U.S. DOE, Preliminary Technical Support Document, "Energy Efficiency Program for Commercial Equipment: Energy Conservation Standards for Electric Motors, 2.7.2 Impact of Repair on Efficiency." July 23, 2012. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/50. Download TSD at: http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/em_preanalysis_tsdallchapters.pdf .

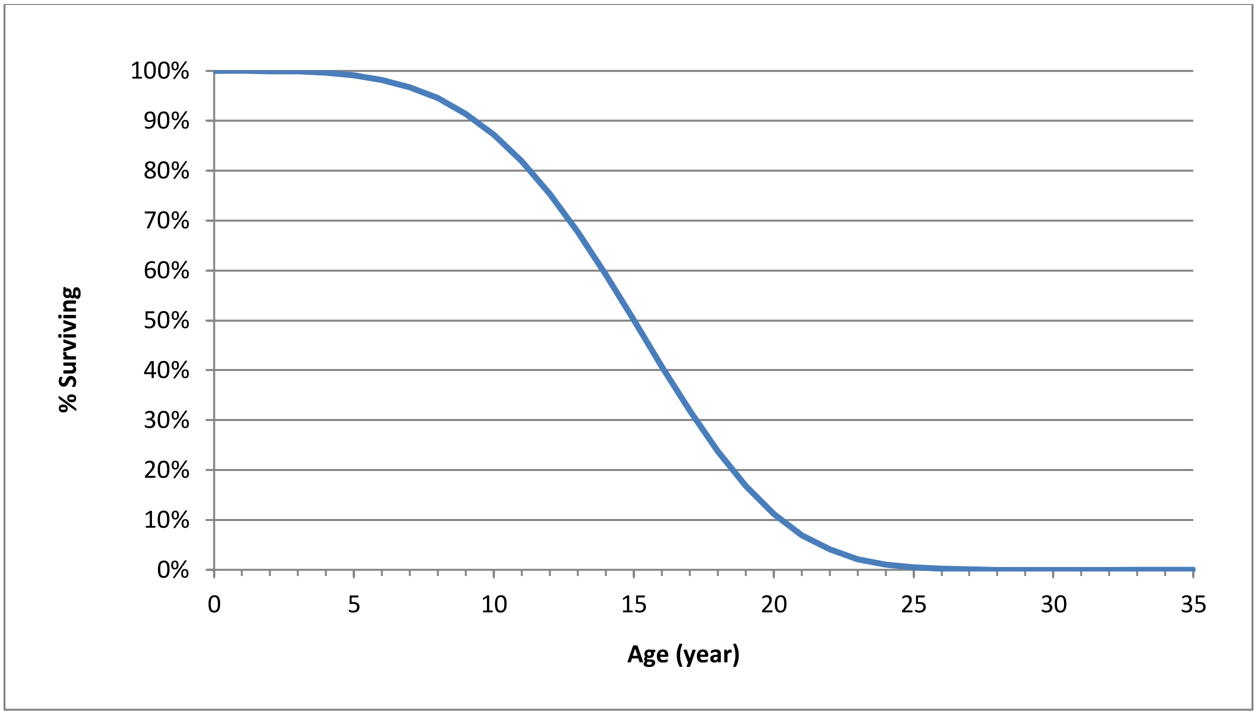

Figure D-1: Survival Function for Premium Efficiency Motors[406]

The method used for estimating the RUL of a replaced system uses the age of the existing system to re-estimate the survival function shown in Figure D-1. The age of the system being replaced is found on the horizontal axis and the corresponding percentage of surviving systems is determined from the chart. The surviving percentage value is then divided in half, creating a new percentage. Then the age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced.

[406] Source: Weibull distribution based on the Life Cycle Cost Analysis Spreadsheet, "lcc_cuac_hourly.xls".

http://www1.eere.energy.gov/buildings/appliance_standards/standards_test_procedures.html.

D.1.2.5. Incremental Cost

Table D-10: Motor Incremental Cost by Size[407]

Motor Horsepower	Incremental Cost
5	$918
7.5	$918
10	$918
15	$918
20	$933
25	$1,012
30	$1,091
40	$1,300
50	$1,497
60	$1,796
75	$1,943
100	$2,389
125	$3,087
150	$3,784
200	$4,555
250	$4,655
300	$4,755
350	$4,855
400	$4,955
450	$5,055
500	$5,155

D.1.2.6. Future Studies

In Energy Smart and other utility portfolios, this is typically a low-volume measure. High-saving motor applications are more commonly found in custom applications. As a result, the TPE does not advise funding future measure research, and recommend that the measure receive updated only when applicable codes or standards warrant it.

[407] Comprehensive Process and Impact Evaluation of the (Xcel Energy) Colorado Motor and Drive Efficiency Program, FINAL, March 28, 2011,TetraTech

D.2. Commercial Water Heating

D.2.1. Water Heater Replacement

D.2.1.1. Measure Description

This measure involves:

- The replacement of electric water heaters in commercial buildings by high efficiency electric resistance water heaters
- The replacement of electric water heaters in commercial buildings by heat pump water heaters
- The replacement of small (< 12 kW) electric water heaters in commercial buildings by electric tankless water heaters

Commercial water heater savings are measured per location and are calculated for new construction or replace-on-burnout. Storage tank models and tankless models, utilizing electricity are eligible.

D.2.1.2. Baseline and Efficiency Standards

The baseline standards for IECC 2009 are detailed in Table D-11.

Table D-11: Commercial Water Heaters – Water Heater Performance Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[408,409]	Test Procedure
Water heaters, electric	≤ 12 kW	Resistance	IECC 2009: 0.97 - 0.00132V, EF	DOE 10 CFR Part 430
	> 12 kW		1.73V + 155, SL (Btu/hr)	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat Pump	0.93 - 0.00132V, EF	DOE 10 CFR Part 430

For smaller water heaters where energy factor (EF) is used, EF takes into account the overall efficiency, including combustion efficiency and standby loss (SL). Regulated by DOE as "residential water heaters", these smaller water heaters manufactured on or after April 16, 2015 must comply with the amended standards found in the Code of Federal Regulations, 10 CFR 430.32(d), detailed in Table D-12.

[408] Energy factor (EF) and thermal efficiency (Et) are minimum requirements. In the EF equation, V is the rated volume in gallons.

[409] Standby loss (SL) is the maximum Btu/hr based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/hr. In the SL equation for electric and gas water heaters and boilers, V is the rated volume in gallons.

Table D-12: Small Commercial Water Heaters – Standards and their Compliance Dates[410]

Product Class	Energy Factor as of April 16, 2015
Electric Water Heater	For Vs < 55 gallons: 0.960 – (0.0003V) For Vs > 55 gallons: 2.057 – (0.00113V)

For larger water heaters, thermal efficiency (Et) is used and does not factor into SL; however, a limitation on SL is noted.

The savings calculations consider the minimum water heater efficiency requirements listed in Table D-11 to be the baseline.

D.2.1.3. Estimated Useful Life (EUL)

The estimated useful life (EUL) of this measure is dependent on the type of water heating. According to DEER 2014, the following measure lifetimes should be applied.[411]

- 10 years for Heat Pump Water Heater (HPWH)
- 15 years for High Efficiency Commercial Storage Water Heater
- 20 years for Commercial Tankless Water Heater

D.2.1.4. Deemed Savings Values

Program staff should endeavor to collect unit-specific information to support energy savings calculations. However, if such data is not available the tables below may be used. The assumptions are as follows:

- Electric Resistant Water Heating:
  - Assume full facility load met by a series of 50-gallon units
  - Resulting baseline EF is .945
  - Efficient EF is .98
- Heat Pump Water Heating:
  - Assume full facility load met by a series of 200-gallon units
  - Resulting baseline EF is 2.00
  - Efficient EF is 2.20

[410] Where V is the rated storage volume, which equals the water storage capacity of a water heater (in gallons), as certified by the manufacturer.

[411] http://www.deeresources.com/files/deer2008exante/downloads/EUL_Summary_10-1-08.xls

Table D-13: Deemed Savings: Electric Resistant Water Heaters

Building Type	Annual Hot Water / 1,000 ft.[2]	Average ft.[2]	kWh Savings	kW Savings
Convenience Store	4,255	2,800	50	0.0057
Education	6,746	45,000	1,267	0.1446
Grocery	646	21,300	57	0.0065
Health	22,734	72,000	6,829	0.7796
Large Office	1,686	95,000	668	0.0763
Large Retail	1,254	80,000	419	0.0478
Lodging	27,399	76,500	8,745	0.9983
Nursing	28,279	72,000	8,495	0.9697
Restaurant	41,224	3,850	662	0.0756
Small Office	1,428	6,000	36	0.0041
Small Retail	5,660	6,400	151	0.0172
Warehouse	1,148	14,000	67	0.0076
Other Commercial	3,652	4,000	61	0.0070

Table D-14: Deemed Savings: Heat Pump Water Heaters

Building Type	Annual Hot Water / 1,000 ft.[2]	Average ft.[2]	kWh Savings	kW Savings
Convenience Store	4,255	2,800	60	0.0068
Education	6,746	45,000	1,523	0.1739
Grocery	646	21,300	69	0.0079
Health	22,734	72,000	8,214	0.9376
Large Office	1,686	95,000	804	0.0917
Large Retail	1,254	80,000	503	0.0575
Lodging	27,399	76,500	10,518	1.2007
Nursing	28,279	72,000	10,217	1.1663
Restaurant	41,224	3,850	796	0.0909
Small Office	1,428	6,000	43	0.0049
Small Retail	5,660	6,400	182	0.0207
Warehouse	1,148	14,000	81	0.0092
Other Commercial	3,652	4,000	73	0.0084

D.2.1.5. Calculation of Deemed Savings

Typically, two types of ratings exist for water heaters: energy factor (EF) for smaller units, and thermal efficiency (Et) for larger water heaters. Large heat pump water heaters may also be rated by a third method, coefficient of performance (COP), which is the ratio of heat energy output to electrical energy input and is analogous to thermal efficiency. EF includes standby losses, while Et and COP only consider the amount of energy required to heat the water. Therefore, in the formulas below, the baseline and energy efficiency measure may be compared for each type of water heater.

The electricity savings for this measure are highly dependent on the estimated hot water consumption, which varies significantly by building type. The following tables list estimated hot water consumption for various building types by number of units, occupants, or building size.

Table D-15: Hot Water Requirements by Building Type and System Capacity[412]

Building Type	Annual Hot Water Consumption Per Gallon of Rated Capacity
Convenience Store	489
Education	526
Grocery	489
Health	730
Large Office	474
Large Retail	489
Lodging	663
Nursing	623
Restaurant	577
Small Office	474
Small Retail	489
Warehouse	316
Other Commercial	316

Table D-16 converts the values from Table D-15 into per-1,000 square feet value based on the same CBECS 2012 data.

[412] Methodology based on TPE analysis. Annual hot water usage in gallons based on CBECS (2012) and RECS (2009) consumption data of West South Central (removed outliers of 1,000 kBtuh or less) to calculate hot water usage. Annual hot water gallons per tank size gallons based on the tank sizing methodology found in ASHRAE 2011 HVAC Applications. Chapter 50 Service Water Heating. Demand assumptions (gallons per day) for each building type based on ASHRAE Chapter 50 and to LBNL White Paper. LBL-37398 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End Use Forecasting. Assumes hot water heater efficiency of 80.

Table D-16: Hot Water Requirements by Building Size413

Building Type	***Annual Hot Water Consumption Per 1,000 square feet***
Convenience Store	4,255
Education	6,746
Grocery	646
Health	22,734
Large Office	1,686
Large Retail	1,254
Lodging	27,399
Nursing	28,279
Restaurant	41,224
Small Office	1,428
Small Retail	5,660
Warehouse	1,148
Other Commercial	3,652

D.2.1.5.1. Small Electric Storage Water Heaters

As small (≤ 12 kW) electric water heaters are typically rated by EF, this section of this measure includes both higher-efficiency resistance water heaters and small (≤ 24 amps and ≤ 250 volts) heat pump water heaters. Deemed annual energy savings for small electric water heater replacements are calculated by formulas as follows:

$$kWh_{Savings} = \frac{\rho \times C_p \times V \times \left(T_{SetPoint} - T_{Supply}\right) \times \left(EF_{pre} - EF_{post}\right)}{3{,}412\ Btu/kWh}$$

Where:

ρ = Water density = 8.33 lb/gal

C_p = Specific heat of water = 1 BTU/lb.·°F

V = Average annual hot water use (gallons). See for Table D-15 and Table D-16 estimates of water consumption.

$T_{SetPoint}$ = Water heater set point (default value = 120°F)

[413] This is a conversion of the capacity values to a per-square foot value based on average building size in the CBECS.

T_{Supply} = Average New Orleans area supply water temperature, 74.8°F[414]

EF_{pre} = Calculated energy factor of existing water heater, based on the water heater tank volume; Table D-11.

EF_{post} = Energy Factor of replacement water heater (taken from nameplate); the replacement water heater may be either a high efficiency electric storage water heater or a heat pump water heater

$Conversion\ Factor$ = 3,412 Btu/kWh

Deemed demand savings for small electric water heater replacements are calculated by formula as follows:

$$kW_{reduction} = \frac{\rho \times C_p \times V \times (T_{SetPoint} - T_{Supply}) \times (EF_{pre} - EF_{post})}{3{,}412\ Btu/kWh} \times 1/24 \times 1/365$$

Where all variables are the same as in the energy equation and the average hourly ratio is a best estimate of peak coincidence for commercial hot water heater replacements.[415]

D.2.1.5.2. Large Electric Storage Water Heaters

Large (> 12 kW) electric resistance water heaters can be replaced with heat pump water heaters.

For replacement of large electric resistance water heaters with a heat pump water heater, deemed annual energy savings are calculated by the following formula:

$$kWh_{Savings} = \frac{\rho \times C_p \times GPD \times (T_{SetPoint} - T_{Supply}) \times \left(\frac{1}{E_{t,base}} - \frac{1}{COP_{post}}\right) \times Days/Year}{3{,}412\ Btu/kWh}$$

Where:

ρ = Water density = 8.33 lb/gal

C_p = Specific heat of water = 1 BTU/lb·°F

V = Average daily hot water use (gallons). See Table D-15 and Table D-16 for estimates of water consumption

$T_{SetPoint}$ = Water heater set point (default value = 120°F)

T_{Supply} = Average New Orleans area supply water temperature, 74.8°F

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414 Calculated using area groundwater data. See Section **Error! Reference source not found.**.

415 For replacement with high-efficiency electric storage water heaters and tankless water heaters, the 1/24 peak coincidence factor accurately reflects that improvements in the efficiency of electric resistance storage water heaters are driven almost entirely by reductions in storage losses (conversion efficiency, RE, is close to 1), which are distributed evenly throughout the day.

$E_{t,base}$ = .98

COP_{post} = Coefficient of performance of new heat pump water heater

D.2.1.5.3. Demand Savings

Deemed demand savings for replacement of large electric resistance water heaters with a heat pump water heater are calculated by the following formula:

$$kW_{reduction} = \frac{\rho \times C_p \times GPD \times \left(T_{SetPoint} - T_{Supply}\right) \times \left(EF_{pre} - EF_{post}\right)}{3{,}412\ Btu/kWh} \times 1/24$$

Where all variables are the same as in the energy equation and the 1/24 ratio is a best estimate of peak coincidence for commercial hot water heater replacements.

D.2.1.5.4. Incremental Cost

The incremental cost for heat pump water heaters are as follows[416]:

- 50 Gallon: $1,050
- 80 Gallon: $1,050
- 100 Gallon: $1,950

D.2.1.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans businesses and updates for applicable codes.

Current DHW load estimates are based off of CBECS data for the West South region. If there is significant participation, we recommend updating with actual participant loads. Further, a study of commercial DHW setpoints would be warranted.

[416] Cost information is based upon data from “2010-2012 WA017 Ex Ante Measure Cost Study Draft Report”, Itron, February 28, 2014. See “NR HW Heater_WA017_MCS Results Matrix - Volume I.xls” for more information.

D.2.2. Commercial Faucet Aerators

D.2.2.1. Measure Description

This measure consists of installing low-flow faucet aerators in commercial facilities which reduce water usage and save energy associated with heating the water.

D.2.2.2. Baseline and Efficiency Standards

The savings values for low-flow faucet aerators are for the retrofit of existing operational faucet aerators with a flow rate of 2.2 gallons per minute or higher. Facilities that use both gas and electric water heaters are eligible for this measure.

The baseline faucet aerators are assumed to have a flow rate of 2.2 gallons per minute.[417] To qualify for this measure, the flow rate of installed low-flow faucet aerators must be at most 1.5 gallon per minute.[418]

D.2.2.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2014.

D.2.2.4. Deemed Savings

Table D-17 through Table D-19 present the default savings for 1.5, 1.0, and 0.5 GPM aerators, respectively. The results are presented by facility type, with the "unknown" category being an average of the listed facility types.

Table D-17: Faucet Aerator Deemed Savings – 1.5 GPM

Building Type	***Days/Year***	***Minutes/Day***	***kWh Savings***	***kW Savings***
Hospital, Nursing home	365	3	86	0.0071
Dormitory	274	30	648	0.0946
Multifamily	365	3	86	0.0071
Lodging	365	3	86	0.0047
Commercial	250	30	591	0.1892
School	200	30	473	0.1183
Unknown	303	17	329	0.0702

[417] Maximum flow rate federal standard for lavatories and aerators set in Federal Energy Policy Act of 1992 and codified at 2.2 GPM at 60 psi in 10CFR430.32.

[418] "High-Efficiency Lavatory Faucet Specification." WaterSense. EPA. October 1, 2007. http://www.epa.gov/watersense/partners/faucets_final.html

Table D-18: Faucet Aerator Deemed Savings – 1.0 GPM

Building Type	Days/Year	Minutes/Day	kWh Savings	kW Savings
Hospital, Nursing home	365	3	148	0.0122
Dormitory	274	30	1,111	0.1622
Multifamily	365	3	148	0.0122
Lodging	365	3	148	0.0081
Commercial	250	30	1,014	0.3244
School	200	30	811	0.2028
Unknown	303	17	563	0.1203

Table D-19: Faucet Aerator Deemed Savings – 0.5 GPM

Building Type	Days/Year	Minutes/Day	kWh Savings	kW Savings
Hospital, Nursing home	365	3	210	0.0172
Dormitory	274	30	1,574	0.2298
Multifamily	365	3	210	0.0172
Lodging	365	3	210	0.0115
Commercial	250	30	1,436	0.4596
School	200	30	1,149	0.2873
Unknown	303	17	798	0.1704

D.2.2.5. Calculation of Deemed Savings

Annual kWh electric and peak kW savings can be calculated using the following equations:

$$kWh\ Savings = \frac{\rho \times C_P \times U \times (F_B - F_P) \times \left(T_H - T_{Supply}\right) \times \frac{1}{E_t} \times Days/Year}{3{,}412\ Btu/kWh}$$

$$kW_{reduction} = \frac{\rho \times C_P \times U \times (F_B - F_P) \times \left(T_H - T_{Supply}\right) \times \frac{1}{E_t} \times P}{3{,}412\ Btu/kWh}$$

Table D-20: Commercial Aerator Savings Parameters

Parameter	Description	Value
F_B	Average baseline flow rate of aerator (GPM)	2.2
F_P	Average post measure flow rate of aerator (GPM)	≤1.5
Days/Year	Annual Building type operating days for the applications:	
	1.Hospital, Nursing home	365
	2. Dormitory	274[419]
	3. Multifamily	365
	4. Lodging	365
	5. Commercial	250
	6. School	200
T_{supply}	Average supply (cold) water temperature (°F)	74.8
T_H	Average mixed water (after aerator) temperature (°F)	120[420]
U	Baseline water usage duration, following applications	
	1. Hospital, Nursing home	3 min/day/unit
	2. Dormitory	30 min/day/unit
	3. Multifamily	3 min/day/unit
	4. Lodging	3 min/day/unit
	5. Commercial	30 min/day/unit
	6. School	30 min/day/unit
ρ	Unit conversion: 8.33 pounds/gallon	8.33
C_p	Heat capacity of water - 1 Btu/lb. °F	1
E_t	Thermal Efficiency of water heater	Default Values: 0.98 for electric resistance, 2.2 (COP) for heat pump
	Hourly water consumption during peak period as a fraction of average daily consumption for applications:	
	1. Hospital, Nursing home	0.03
	2. Dormitory	0.04
	3. Multifamily	0.03
	4. Lodging	0.02
	5. Commercial	0.08
	6. School	0.05

Example: The following is an electric example calculation for a 1.0 GPM aerator replacement for a school using the previous equations and information. Example electric

[419] Dormitories with few occupants in the summer: 365 x (9/12) = 274.

[420] Calculated based on area groundwater temps.

savings are based on heating water with a conventional electric resistance storage tank water heater.

$$\Delta kWh = [8.33\ x\ 30minday\ x\ (2.2 - 1.0)\ GPM\ x\ (120 - 74.8°F)\ x\ (1/.98) * 200dayyear]/3412\ Btu/kWh$$

$$= 811\ kWh$$

$$\Delta kW = [8.33\ x\ 30minday\ x\ (2.2 - 1.0)\ GPM\ x\ (120 - 74.8°F)\ \text{x}\ (1/.98)\ x\ .05]/3412\ Btu/kWh$$

$$= 0.202\ kW$$

D.2.2.6. Incremental Cost

Program-actual costs should be used where available. If not available, the incremental cost of a faucet aerator is $8.00[421].

D.2.2.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans businesses and updates for applicable codes.

If there is significant participation, we recommend updating with actual participant loads. Further, a study of commercial DHW setpoints would be warranted.

[421] Direct-install price per faucet assumes cost of aerator and install time. (2011, Market research average of $3 and assess and install time of $5 (20min @ $15/hr)

D.2.3. Commercial Low-Flow Showerheads

D.2.3.1. Measure Description

This measure consists of removing existing showerheads and installing low-flow showerheads at the following commercial building types: hospitals and nursing homes, lodging facilities, commercial facilities (offices or other commercial buildings in which showers are provided for employees), fitness centers, and schools.[422]

D.2.3.2. Baseline and Efficiency Standards

The savings values for low-flow showerheads are for the retrofit of existing operational showerheads with a flow rate of 2.5 gallons per minute (GPM) or higher.[423] Facilities must have electric water heating to qualify for this measure.

The baseline showerhead has an average flow rate of 2.5 GPM based on the current DOE standard. To qualify for the deemed savings, replacement showerheads must have a flow rate of 2.0 GPM or less.[424]

Existing showerheads that have been defaced so as to make the flow rating illegible are not eligible for replacement. Low flow shower heads that are easily tampered with should not be used. Removed showerheads shall be collected by the contractor and held for possible inspection by the utility until all inspections for invoiced installations have been completed.

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[422] This measure draws from multiple sources, including the residential low flow showerhead measure and commercial faucet aerator measure. Information specific to hot water use in commercial market sectors was drawn from CLEAResult, Inc. draft white paper: *Work Papers for Low Flow Shower Heads with Gas or Electric Water Heaters: Savings Calculation Methodology for Application in Arkansas Energy Efficiency Programs*, February 2014.

[423] 10 CFR Part 430, Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirements for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule, March 1998. Online. Available: http://www.regulations.gov/#!documentDetail;D=EERE-2006-TP-0086-0003.

[424] The U.S. Environmental Protection Agency (EPA) WaterSense Program has a thorough specification for showerheads that meet a maximum flow rate of 2.0 gpm. The specification is available on the EPA website at: www.epa.gov/WaterSense/partners/showerhead_spec.html

Table D-21: Low-Flow Showerhead – Baseline and Efficiency Standards

Measure	New Showerhead Flow Rate[425] (GPM)	Existing Showerhead Baseline Flow Rate (GPM)
2.0 GPM showerhead	2.0	2.5
1.75 GPM showerhead	1.75	2.5
1.5 GPM showerhead	1.5	2.5

The U.S. Environmental Protection Agency (EPA) WaterSense Program has implemented efficiency standards for showerheads requiring a maximum flow rate of 2.0 GPM[426].

D.2.3.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2014.

D.2.3.1. Deemed Savings

Table D-22 through Table D-24 present the default savings for 1.5, 1.0, and 0.5 GPM aerators, respectively. The results are presented by facility type, with the "unknown" category being an average of the listed facility types. For the "unknown" facility type, the values are the average of all other facilities excluding Fitness Center; this facility is a high outlier in savings and the TPE has opted to exclude it from the "unknown" category due to the risk of this facility skewing results.

Table D-22: Showerhead Deemed Savings – 2.0 GPM

Building Type	Hot Water Reduction	kWh Savings	kW Savings
Hospital / Nursing home	232	26.11	0.7844
Hospitality	326	36.67	0.7345
Commercial (General) - Employee Shower	253	28.46	2.2798
Fitness Center	5203	584.96	46.8656
Schools	344	38.72	1.9390
Unknown	288.75	32.49	1.4642

425 All flow rate requirements listed here are the rated flow of the showerhead measured at 80 pounds per square inch of pressure (psi).

426 http://www1.eere.energy.gov/femp/program/waterefficiency_bmp7.html.

Table D-23: Showerhead Deemed Savings – 1.75 GPM

Building Type	Hot Water Reduction	kWh Savings	kW Savings
Hospital / Nursing home	348	39.16	1.1766
Hospitality	489	55.01	1.1017
Commercial (General) - Employee Shower	380	42.68	3.4197
Fitness Center	7,804	877.44	70.2984
Schools	517	58.09	2.9085
Unknown	433.5	48.73	2.1963

Table D-24: Showerhead Deemed Savings – 1.5 GPM

Building Type	Hot Water Reduction	kWh Savings	kW Savings
Hospital / Nursing home	464	52.22	1.5688
Hospitality	652	73.34	1.4690
Commercial (General) - Employee Shower	506	56.91	4.5596
Fitness Center	10,405	1169.93	93.7312
Schools	689	77.45	3.8780
Unknown	577.75	64.98	2.9284

D.2.3.2. Calculation of Deemed Savings

Energy and demand savings are estimated as functions of the reduction in daily water use (ΔV) attributable to installation of low flow showerheads in a given commercial building type. Reduction in water use and deemed savings calculations make use of the data provided by building type in Table D-25 and the New Orleans average water main temperature, 74.8.

Table D-25: Showers per Day (per Showerhead) and Days of Operation by Building Type

Building Type	Showers/ Day	Days/Year
Hospital/Nursing home	0.89	365
Hospitality	1.25	365
Commercial	0.97	250
Fitness Center	19.94	365
School	1.32	200

D.2.3.3. Estimated Hot Water Usage Reduction

Reduction in annual hot water usage is estimated based on the typical duration of a shower and the expected number of showers per year for an installed showerhead in a given facility.

Reduction in daily hot water consumption is estimated on a per-showerhead basis using the following formula:

$$\Delta V = U \times N \times (Q_B - Q_P) \times F_{HW}$$

Where:

ΔV = Reduction in daily hot water use in gallons per day (GPD)

U = Typical shower duration of 7.8 (minutes/shower)

N = Number of showers per day (per showerhead); (N) is a function of the commercial building type, values for N are provided in Table D-27.

Q_B = Baseline showerhead flow rate, 2.5 GPM

Q_P = Flow rate of installed showerhead (in GPM)

F_{HW} = Hot Water Fraction (share of water flowing through showerhead from the water heater, %)

The fraction of hot water is a function of the inlet water temperature (T_{supply}) the temperature of water from the hot water heater (T_{HW} = 120 ºF), and the desired temperature at the showerhead (T_{mixed} = 105 ºF).

Reduction in daily hot water usage is provided for reference in Table D-26.

Table D-26: Reduction in Daily Hot Water Usage, ΔV (GPD)

Flow Rate of installed showerhead	**Building Type**				
	Hospital / Nursing home	**Hospitality**	**Commercial (General) - Employee Shower**	**Fitness Center**	**Schools**
2.0 GPM	232	326	253	5,203	344
1.75 GPM	348	489	380	7,804	517
1.5 GPM	464	652	506	10,405	689

D.2.3.3.1. Energy Savings

The deemed energy savings are calculated as follows:

$$kWh_{savings} = \frac{\rho \times C_P \times \Delta V \times \left(T_{HW} - T_{Supply}\right) \times \left(\frac{1}{E_t}\right)}{Conversion\ Factor}$$

Where:

ρ = Water density = 8.33 lb/gallon

C_P = Specific heat of water = 1 Btu/lb·°F

ΔV = gallons of hot water saved per day (GPD, calculated above identified in Table D-26)

T_{HW} = Temperature to which water is heated in the water heater, 120°F

T_{Supply}= Average inlet water temperature (water mains temperature), 74.8.

E_t = Thermal efficiency of water heater (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters[427]

$Conversion\ Factor$ = 3,412 Btu/kWh for electric water heating or 100,000 Btu/therm for gas water heating

D.2.3.3.2. Demand Savings

The deemed demand savings are calculated as follows:

$$kW_{reduction} = \frac{\rho \times C_P \times \Delta V \times (T_{HW} - T_{Supply}) \times \left(\frac{1}{E_t}\right)}{Conversion\ Factor}\ x\ P$$

Where:

All inputs are the same as described in the Energy Savings Equation and

P = electric peak coincidence factors, as provided for each building type in Table D-27. [428]

D.2.3.3.3. Parameters for Annual Energy and Peak Demand Savings Calculations

[427] Default values based on median recovery efficiency of commercial water heaters by fuel type in the AHRI database as cited in previous iterations of the AR TRM. Online: available at http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH.

[428] For all building types except 24-Hour Fitness Centers, derived from *ASHRAE Handbook 2011. HVAC Applications.* American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) 2011. ASHRAE, Inc., Atlanta, GA. The peak factor is the ratio of the gallons of hot water used during the peak times of 3pm to 6pm, to the total amount of hot water used during the day. 24-Hour Fitness Center is assigned the same value as Commercial.

Table D-27: Parameters for Annual Energy and Peak Demand Savings Calculations

Parameter	Description	Value
U	Baseline shower duration[429] (min/shower)	7.8
N	Number of showers per day per showerhead[430] 1. Hospital, Nursing Home 2. Lodging 3. Commercial 4. 24-Hour Fitness Center 5. Schools	 0.89 1.25 0.97 19.94 1.32
Q_B	Average baseline flow rate of showerhead (GPM)	2.5
Q_P	Flow rate of installed showerhead (GPM)	≤ 2.0
F_{HW}	Share of water flowing through showerhead coming from the water heater (%)	66.9
ρ	Density of water (lb./gal)	8.33
Cp	Heat capacity of water (Btu/lb.-ºF)	1
T_{HW}	Temperature to which water is heated by the water heater (ºF)[431]	120
T_{supply}	Average supply (cold) water temperature (ºF)	74.8
E_t	Thermal Efficiency of hot water heater: ▪ Conventional Electric Storage Water Heater ▪ Heat Pump Water Heater (COP) ▪ Gas Storage Water Heater	 0.98 2.2 0.80
$Days/year$	Annual building type operating days for the applications:[432] 1. Hospital, Nursing Home 2. Lodging 3. Commercial 4. 24-Hour Fitness Center 5. School	 365 365 250 365 200

[429] Hendron, R., & Engebrech, C. 2010, "*Building America Research Benchmark Definition, Updated December 2009, Technical Report NREL/TP-550-47246,* January. National Renewable Energy Laboratory The average shower duration taken from Table 12, p. 20.

[430] Primary source is Northwest Power and Conservation Council ProCost V2.3. The number of showers per day per showerhead is back-calculated for hospitals and nursing homes, lodging and commercial building types, coefficients from annual minutes per showerhead estimates. N = (Minutes/year) x (year/days) x (Shower/minutes) = Showers/day. For 24-hour fitness centers, minutes per year were taken from informal telephone survey of Fitness Centers in the Northwest, conducted by Northwest Power and Conservation Council Regional Technical Forum staff in June, 2013. The estimate for schools is derived from Water consumption from Planning and

Parameter	Description	Value
P	Peak Factor:[433] 1. Hospital, Nursing Home 2. Lodging 3. Commercial 4. 24-Hour Fitness Center 5. School	0.03 0.02 0.08 0.08 0.05

D.2.3.4. Incremental Cost

Program-actual costs should be used where available. If not available, the incremental cost of a low flow showerhead is $12.00[434].

D.2.3.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans business and updates for applicable codes.

If there is significant participation, we recommend updating with actual participant loads. Further, a study of commercial DHW setpoints would be warranted.

Management Consultants, Ltd., Aquacraft, Inc. and John Olaf Nelson, Water Resources Management. "*Commercial and Institutional End Uses of Water,*" American Water Works Association Research Foundation, 2000.

[431] ASHRAE Handbook 2011. HVAC Applications. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE), Inc., Atlanta, GA.

[432] All values except 24-Hour Fitness Center from Osman , S. & Koomey, J. Lawrence Berkeley National Laboratory 1995. *Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting.* December 1995. Value for 24-Hour Fitness Center based on observation.

[433] Derived from *ASHRAE Handbook 2011. HVAC Applications.* American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) 2011. ASHRAE, Inc., Atlanta, GA. The peak factor is the ratio of the gallons of hot water used during the peak times of 3 pm to 6pm, to the total amount of hot water used during the day.

[434] Direct-install price per showerhead assumes cost of showerhead (Market research average of $7 and assess and install time of $5 (20min @ $15/hr)

D.2.4. Commercial Water Heater Pipe Insulation

D.2.4.1. Measure Description

This measure consists of installing water heater pipe insulation exceeding the IECC mandated standard (0.5-inch of insulation that delivers an R-value of at least 3.7 per inch) over at least the first 8 feet of exposed pipe in small commercial settings. Water heaters plumbed with heat traps or automatic-circulating systems are not eligible to receive incentives for this measure.[435]

D.2.4.2. Baseline and Efficiency Standards

Baseline insulation is R = 1.85 sq. ft. h °F/Btu, the mandated standard since IECC 2000.

D.2.4.3. Estimated Useful Life (EUL)

The estimated useful life (EUL) of this measure is the remaining service life of the water heater. If unknown, use one-third of the life of an electric resistant water heater, rounded down. This is a measure life of 4 years.[436]

D.2.4.4. Deemed Savings Values

The TPE assume three feet of R-3 insulation in providing an estimate of per-project savings. Program administrators are encouraged to incorporate facility-specific inputs when possible. Deemed savings are:

- 112 kWh;
- .0128 kW

D.2.4.5. Calculation of Deemed Savings

D.2.4.5.1. Energy Savings

$$kWh_{savings} = \left(U_{pre} - U_{post}\right) \times A \times \left(T_{Pipe} - T_{ambient}\right) \times \left(\frac{1}{E_t}\right) \times \frac{Hours_{Total}}{Conversion\ Factor}$$

Where:

U_{pre}= 1/(2.03[437]) = 0.49 BTU/h sq. ft. degree F

U_{post}= 1/(2.03+$R_{Insulation}$)

$R_{Insulation}$= R-value of installed insulation

[435] A survey of several large online home-improvement retailers shows three general classes of commercially available pipe insulation: one around R-2.3 (typically 5/8" thick foam), another around R-3 (typically 1/2" thick rubber) and lastly high-end insulation in the R-6 to R-7 range (1" thick rubber).

[436] To see water heater EUL, go to Section D.2.1.3.

[437] 2.03 is the R-value representing the film coefficients between water and the inside of the pipe and between the surface and air. *Mark's Standard Handbook for Mechanical Engineers, 8th edition*.

A = Surface area in square feet (πDL) with L (length) and D pipe diameter in feet

$T_{Pipe}(°F)$ = Average temperature of the pipe. Default value = 90 °F (average temperature of pipe between water heater and the wall)

$T_{ambient}(°F)$ = 68.78°F (New Orleans TMY3 average hourly temperature)

Et = Thermal efficiency (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric water heaters, 2.2 for a heat pump water heater.[438]

$Hours_{Total}$ = 8,760 hr per year[439,440]

$Conversion\ Factor$ = 3,412 Btu/kWh for electric water heating or 100,000 Btu/Therm for gas water heating.

For example, deemed savings for water heater pipe insulation with an R-value of 3 installed on an electric water heater in New Orleans would be:

$$kWh_{savings} = (0.49 - 0.20) \times 2.1 \times (90 - 74.8) \times \left(\frac{1}{0.98}\right) \times \frac{8,760}{3,412} = 24.3\ kWh/yr$$

D.2.4.5.2. Demand Savings

Peak demand savings for hot water heaters installed in conditioned space can be calculated using the following formula for electric demand savings:

$$kW_{reduction} = (U_{pre} - U_{post}) \times A \times (T_{Pipe} - T_{ambientMAX}) \times \left(\frac{1}{E_t}\right) \times \frac{1}{3,412\ Btu/kWh}$$

Where:

U_{pre} = 1/(2.03) =0.49 BTU/h sq. ft. degree F

U_{post} = 1/(2.03+$R_{Insulation}$)

$R_{Insulation}$ = R-value of installed insulation

A = Surface area in square feet (πDL) with L (length) and D pipe diameter in feet

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438 Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at https://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx

439 Ontario Energy's Measures and Assumptions for Demand Side Management (DSM) Planning www.ontarioenergyboard.ca/OEB/_Documents/EB-2008-0346/Navigant_Appendix_C_substantiation_sheet_20090429.pdf

440 New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Residential, Multi-Family, and Commercial/Industrial Measures http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/06f2fee55575bd8a852576e4006f9af7/$FILE/TechManualNYRevised10-15-10.pdf

$T_{Pipe}(°F) =$ Average temperature of the pipe. Default value = 90 °F (average temperature of pipe between water heater and the wall)

$T_{ambientMAX}(°F)$ =For water heaters installed in unconditioned basements, use an average ambient temperature of 68.78°F; for water heaters inside the thermal envelope, use an average ambient temperature of 78 °F

Et = Thermal efficiency (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric water heaters, 2.2 for a heat pump water heater.

D.2.4.6. Incremental Cost

The incremental cost of a Water Heater Pipe Insulation is equal to the full installed cost. If the cost is unknown, use $4.45 for ¾" pipe and $4.15 for ½" pipe per linear foot of insulation[441].

D.2.4.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units purchased by New Orleans businesses and updates for applicable codes.

[441] Illinois TRM

D.3. HVAC

D.3.1. Packaged Terminal AC/HP (PTAC/PTHP) Equipment

D.3.1.1. Measure Description

This measure requires the installation of a PTAC or PTHP. AHRI Test Standard 310/380-2004 defines a PTAC or PTHP as "a wall sleeve and a separate non-encased combination of heating and cooling assemblies specified by the manufacturer and intended for mounting through the wall. It includes refrigeration components, separable outdoor louvers, forced ventilation, and heating availability by purchaser's choice of, at least, hot water, steam, or electrical resistance heat." These definitions are consistent with federal code (10 CFR Part 431.92).

PTAC/PTHP equipment is available in standard and non-standard sizes. Standard size refers to PTAC/PTHP equipment with wall sleeve dimensions having an external opening greater than or equal to 16 inches high or greater than or equal to 42 inches wide, and a cross-sectional area greater than or equal to 670 square inches. Non-standard size refers to PTAC/PTHP equipment with existing wall sleeve dimensions having an external wall opening of less than 16 inches high or less than 42 inches wide, and a cross-sectional area less than 670 square inches.

D.3.1.2. Baseline and Efficiency Standards

The baseline for units that are used in new construction or are replaced on burnout is the current federal minimum standard,[442] which went into effect September 30, 2012 for standard sized units and September 30, 2010 for non-standard sized units (Table D-28).

[442] 2010 U.S. Code: Title 42, Chapter 77, Subchapter III, Part A-1, Section 6313.

Table D-28: PTAC/PTHP Equipment – Baseline Efficiency Levels

Equipment Type	Size Category	Capacity (Btu/h)	Minimum Efficiency [443]
PTAC	Standard	< 7,000	EER = 11.7
		7,000 – 15,000	EER = 13.8 – (0.300 x CAP)
		> 15,000	EER = 9.3
	Non-Standard	< 7,000	EER = 9.4
		7,000 – 15,000	EER = 10.9 – (0.213 x CAP)
		> 15,000	EER = 7.7
PTHP	Standard	< 7,000	EER = 11.9 COP = 3.3
		7,000 – 15,000	EER = 14.0 – (0.300 x CAP) COP = 3.7 – (0.052 x CAP)
		> 15,000	EER = 9.5 COP = 2.9
	Non-Standard	< 7,000	EER = 9.3 COP = 2.7
		7,000 – 15,000	EER = 10.8 – (0.213 x CAP) COP = 2.9 – (0.026 x CAP)
		> 15,000	EER = 7.6 COP = 2.5

D.3.1.3. Estimated Useful Life (EUL)

The estimated useful life of the measure is 10 years, in accordance with the DOE's Packaged Terminal Air Conditioners and Heat Pumps Energy Conservation Standard Technical Support Document.[444]

D.3.1.4. Deemed Savings Values

For the deemed savings values, the TPE assume a Standard size category, and a capacity of 11,000 BTU (midpoint of the central size category) and a 12 EER/11 HSPF system.

[443] "Cap" refers to cooling capacity in thousand Btu/h.

[444] U.S. DOE, Technical Support Document: "*Packaged Terminal Air Conditioners and Heat Pumps, 3.2.7 Equipment Lifetime*". http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/45.

Table D-29: Deemed Savings by Building Type - PTAC

Building Type	kWh	kW
Fast Food	311	0.102
Grocery	200	0.118
Health Clinic	260	0.111
Large Office	194	0.110
Lodging	274	0.101
Full Menu Restaurant	262	0.111
Retail	418	0.115
School	305	0.093
Small Office	270	0.110
University	198	0.110
Unknown	269	0.1082

Table D-30: Deemed Savings by Building Type - PTHP

Building Type	kWh	kW
Fast Food	293	0.087
Grocery	186	0.100
Health Clinic	234	0.095
Large Office	206	0.094
Lodging	276	0.086
Full Menu Restaurant	240	0.095
Retail	409	0.098
School	274	0.079
Small Office	256	0.094
University	231	0.094
Unknown	257	0.920

D.3.1.5. Calculation of Deemed Savings

Deemed peak demand and annual energy savings for PTAC/PTHP equipment should be calculated using the following formulas:

$$kW_{Savings} = CAP_C \times \frac{1\ kW}{1{,}000\ W} \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right) \times CF$$

$$kWh_{Savings,PTAC} = CAP_C \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right)$$

$$kWh_{Savings,PTHP,C} = CAP_C \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C \times \left(\frac{1}{\eta_{base,C}} - \frac{1}{\eta_{post,C}}\right)$$

$$kWh_{Savings,PTHP,H} = CAP_H \times \frac{1\ kWh}{3{,}412\ \text{BTU}} \times EFLH_H \times \left(\frac{1}{\eta_{base,H}} - \frac{1}{\eta_{post,H}}\right)$$

Where,

CAP_C= Rated equipment cooling capacity of the new unit (BTU/hr.)

CAP_H= Rated equipment heating capacity of the new unit (BTU/hr.)

$\eta base$, = Baseline energy efficiency rating of the baseline cooling equipment (EER)

$\eta post$, = Nameplate energy efficiency rating of the installed cooling equipment (EER)

$\eta post$,= Nameplate energy efficiency rating of the installed heating equipment (COP)

Note: heating efficiencies expressed as a heating seasonal performance factor (HSPF) will need to be converted to a coefficient of performance (COP) using the following equation:

$$\text{COP} = \text{HSPF} \div 3.412$$

3,412 = Constant to convert from BTU/hr. to kWh

CF= Coincidence factor (Table D-32)

$EFLH_c$ = Equivalent full-load hours for cooling (Table D-31)

$EFLH_h$= Equivalent full-load hours for heating (Table D-31)

Table D-31: Equivalent Full-Load Hours by Building Type

Building Type	$EFLH_C$	$EFLH_H$
Fast Food	2,375	272
Grocery	1,526	153
Health Clinic	1,989	115
Large Office	1,483	392
Lodging	2,095	409
Full Menu Restaurant	1,997	166
Retail	3,191	513
School	2,329	140
Small Office	2,060	255
University	1,510	604

Table D-32: Commercial Coincidence Factors by Building Type[445]

Building Type	Coincidence Factor
Fast Food	0.78
Grocery	0.90
Health Clinic	0.85
Large Office	0.84
Lodging	0.77
Full Menu Restaurant	0.85
Retail	0.88
School	0.71
Small Office	0.84
College	0.84

D.3.1.6. Incremental Cost

The incremental cost for this equipment is $84/ton[446]. The average tonnage is assumed to be .92 if unknown, resulting in an incremental cost of $77.

D.3.1.7. Future Studies

Though eligible for Energy Smart, this measure has had little-to-no participation. Until such time as participation produces a minimum of 500,000 kWh in a program year, it is recommended that updates be limited to those needed to reflect code changes.

If this threshold is met, we recommend focusing M&V to update EFLH estimates.

[445] Values for Assembly and Religious Worship building types developed using an adjustment factor derived through a comparison of average CFs for College/University and Assembly/Religious Worship building types from the Texas state Technical Reference Manual. College/University was selected as a reference building type due to average alignment with Assembly/Religious worship building types in other TRMs, inclusion of a summer session, and increased evening usage.

[446] DEER 2014.

D.3.2. Unitary and Split System AC/HP Equipment

D.3.2.1. Measure Description

This measure requires the installation of packaged or split system air conditioners (AC) or heat pumps (HP), excluding PTACs/PTHPs. Unitary or split system ACs/HPs consist of one or more factory-made assemblies that normally include an evaporator or cooling coil(s), compressor(s), and condenser(s). They provide the function of air cooling, and may include the functions of air heating, air circulation, air cleaning, dehumidifying, or humidifying.

D.3.2.2. Baseline and Efficiency Standards

The baseline for units that are used in new construction or are replaced on burnout is the current federal minimum standard,[447] which went into effect January 1, 2010 (Table D-33).

As of January 1, 2015, split system heat pumps < 65,000 Btu/h must comply with 10 CFR 430.32(c)(3) for Residential Central Air Conditioners and Heat Pumps. Split systems are not explicitly covered by originally specified federal standard 10 CFR 431.97 for Commercial package air condition and heating equipment. Split system air conditioners are not affected because the existing SEER and HSPF values remain unchanged.

Table D-33: Unitary AC/HP Equipment – Baseline Efficiency Levels[448]

Equipment Type	***Capacity (Btu/h)***	***Heating Section Type***	***Sub-Category***	***Minimum Efficiency***
Air Conditioners, Air Cooled	< 65,000	All	Split System & Single Package	11.2 EER 13.0 SEER
	≥ 65,000 & <135,000	Electric Resistance (or none)	Split System & Single Package	11.2 EER 11.4 IEER
	≥ 65,000 & <135,000	All other	Split System & Single Package	11.0 EER 11.2 IEER
	≥ 135,000 & <240,000	Electric Resistance (or none)	Split System & Single Package	11.0 EER 11.2 IEER
	≥ 135,000 & <240,000	All other	Split System & Single Package	10.8 EER 11.0 SEER
	≥ 240,000 & <760,000	Electric Resistance (or none)	Split System & Single Package	10.0 EER 10.1 IEER
	≥ 240,000 & <760,000	All other	Split System & Single Package	9.8 EER 9.9 IEER
	≥ 760,000	Electric Resistance (or none)	Split System & Single Package	9.7 EER 9.8 SEER
	≥ 760,000	All other		9.5 EER

[447] 2010 U.S. Code: Title 42, Chapter 77, Subchapter III, Part A-1, Section 6313.

[448] IECC 2012, Table C403.2.3(1) & C403.2.3(2); full-load efficiencies consistent with ASHRAE 90.1-2010, Table 6.8.1A & 6.8.1B and compliant with the federal standard.

			Split System & Single Package	9.6 IEER
Air Conditioners, Water and Evaporatively Cooled[351]	< 65,000	All	Split System & Single Package	12.1 EER 12.3 IEER
	≥ 65,000 & <135,000	Electric Resistance (or none)	Split System & Single Package	11.5 EER 11.7 IEER
	≥ 65,000 & <135,000	All other	Split System & Single Package	11.3 EER 11.5 IEER
	≥ 135,000 & <240,000	Electric Resistance (or none)	Split System & Single Package	11.0 EER 11.2 IEER
	≥ 135,000 & <240,000	All other	Split System & Single Package	10.8 EER 11.0 IEER
	≥ 240,000	Electric Resistance (or none)	Split System & Single Package	11.0 EER 11.1 IEER
	≥ 240,000	All other	Split System & Single Package	10.8 EER 10.9 SEER
Heat Pumps, Air Cooled (Cooling Mode)	< 65,000	All	Single Package	11.2 EER[352] 13.0 SEER
			Single Package (before 1/1/2015)	11.2 EER[353] 13.0 SEER
			Single Package (after 1/1/2015)[354]	11.8 EER[355] 14.0 SEER
	≥65,000 & <135,000	Electric Resistance (or none)	Split System & Single Package	11.0 EER 11.2 IEER
	≥65,000 & <135,000	All other	Split System & Single Package	10.8 EER 11.0 IEER
	≥135,000 & <240,000	Electric Resistance (or none)	Split System & Single Package	10.6 EER 10.7 IEER
	≥135,000 & <240,000	All other	Split System & Single Package	10.4 EER 10.5 IEER
	≥240,000	Electric Resistance (or none)	Split System & Single Package	9.5 EER 9.6 IEER
	≥240,000	All other	Split System & Single Package	9.3 EER 9.4 IEER

Heat Pumps, Air Cooled (Heating Mode)	<65,000	N/A	Single Package	7.7 HSPF
			Single Package (before 1/1/2015)	7.7 HSPF
			Single Package (after 1/1/2015)[356]	8.2 HSPF
	≥65,000 & <135,000	N/A	Split System & Single Package	3.3 COP
	≥135,000	N/A	Split System & Single Package	3.2 COP

D.3.2.3. Estimated Useful Life (EUL)

According to the DEER 2014, the EUL for this measure is 15 years.

D.3.2.1. Deemed Savings Values

This measure has significant variability in equipment capacity and thus a per-unit savings value is not likely to be usable by program administrators. Due to this we present savings in a per-ton basis, assuming 15 SEER, 12.5 EER, and 9.0 HSPF (where applicable.

Table D-34: Deemed Savings by Building Type - AC

Building Type	kWh/Ton	kW/Ton
Fast Food	645	0.2117
Grocery	414	0.2443
Health Clinic	540	0.2307
Large Office	403	0.2280
Lodging	569	0.2090
Full Menu Restaurant	542	0.2307
Retail	866	0.2389
School	632	0.1927
Small Office	559	0.2280
University	410	0.2280
Unknown	558	0.2242

Table D-35: Deemed Savings by Building Type – Heat Pump

Building Type	kWh/Ton	kW/Ton

Fast Food	680	0.2117
Grocery	434	0.2443
Health Clinic	555	0.2307
Large Office	454	0.2280
Lodging	622	0.2090
Full Menu Restaurant	564	0.2307
Retail	933	0.2389
School	650	0.1927
Small Office	592	0.2280
University	488	0.2280
Unknown	597	0.2242

D.3.2.2. Calculated Deemed Savings

Deemed peak demand and annual energy savings for unitary AC and HP equipment should be calculated as shown below. Note that these savings calculations are different depending on whether the measure is replace-on-burnout or early retirement.

$$kW_{Savings} = CAP \times \frac{1\ kW}{1{,}000\ W} \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right) \times CF$$

$$kWh_{Savings,AC} = CAP \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right)$$

$$kWh_{Savings,HP} = CAP \times \frac{1\ kW}{1{,}000\ W} \times \left[\left(\frac{EFLH_C}{\eta_{base,AC}} + \frac{EFLH_H}{\eta_{base,HP}}\right) - \left(\frac{EFLH_C}{\eta_{post,AC}} + \frac{EFLH_H}{\eta_{post,HP}}\right)\right]$$

Where,

CAP = Rated equipment cooling capacity of the new unit (BTU/hr)

$\eta_{base,AC/HP}$ = Baseline energy efficiency rating of the cooling/heating equipment (Table D-33)

$\eta_{post,AC/HP}$= Nameplate energy efficiency rating of the installed cooling/heating equipment

Note: Use EER for kW savings calculations and SEER/IEER and HSPF for kWh savings calculations.

CF = Coincidence factor (

Table *D-37*)

$EFLH_c$ = Equivalent full-load hours for cooling (Table *D-36*)

$EFLH_h$ = Equivalent full-load hours for heating (Table *D-36*)

Table D-36: Equivalent Full-Load Hours by building type

Building Type	***$EFLH_C$***	***$EFLH_H$***
Fast Food	2,375	272
Grocery	1,526	153
Health Clinic	1,989	115
Large Office	1,483	392
Lodging	2,095	409
Full Menu Restaurant	1,997	166
Retail	3,191	513
School	2,329	140
Small Office	2,060	255
University	1,510	604

Table D-37: Commercial Coincidence Factors by Building Type[449]

Building Type	***Coincidence Factor***
Fast Food	0.78
Grocery	0.90
Health Clinic	0.85
Large Office	0.84
Lodging	0.77
Full Menu Restaurant	0.85
Retail	0.88
School	0.71
Small Office	0.84
College	0.84

D.3.2.3. Incremental Cost

Incremental cost is detailed in Table *D-38* below.

[449] Values for Assembly and Religious Worship building types developed using an adjustment factor derived through a comparison of average CFs for College/University and Assembly/Religious Worship building types from the Texas state Technical Reference Manual. College/University was selected as a reference building type due to average alignment with Assembly/Religious worship building types in other TRMs, inclusion of a summer session, and increased evening usage.

Table D-38: Unitary AC Incremental Cost

Capacity	***Cost Per Ton per 1.0 SEER above 14.0***
65,000 Btuh or less	$82
65,000 to 240,000 Btuh	$48
240,000 to 760,000 Btuh	$180
760,000 Btuh or more	$181

D.3.2.1. Future Studies

Though eligible for Energy Smart, this measure has had little-to-no participation. Until such time as participation produces a minimum of 500,000 kWh in a program year, it is recommended that updates be limited to those needed to reflect code changes.

If this threshold is met, we recommend focusing M&V to update EFLH estimates.

D.3.3. Air- and Water-Cooled Chillers

D.3.3.1. Measure Description

This measure requires the installation of any air-cooled or water-cooled chilling package, referred to as a chiller. AHRI Test Standard 550/590-2003 defines a water-chilling package as "a factory-made and prefabricated assembly of one or more compressor, condensers, and evaporators, with interconnections and accessories, designed for the purpose of cooling water. It is a machine specifically designed to make use of a vapor compression refrigeration cycle to remove heat from water and reject the heat to a cooling medium, usually air or water."

The most common applications are for larger cooling loads (e.g., 50 to 100 tons and greater). Chiller types include centrifugal, rotary, screw, scroll, reciprocating, and gas absorption. Absorption chillers are subject to a different AHRI test standard and not reviewed as part of this analysis. When a water-cooled chiller is replacing an air-cooled chiller, the additional auxiliary electrical loads for the condenser water pump and the cooling tower fan have to be considered. Thus, a penalty factor is necessary as a downward adjustment to account for the peak demand and energy savings.

To qualify, the chiller must serve an HVAC load. Chillers used as part of industrial processes require custom analysis.

D.3.3.2. Baseline and Efficiency Standards

The baseline for units that are used in new construction or are replaced on burnout is the current state minimum standard[450] (Table D-39). Two different paths are proposed by IECC 2009. Path A involves installing a chiller that optimizes demand savings (optimizes EER) whereas Path B involves optimizing total energy savings (optimizes IPLV). If the design path is unknown, use Path A efficiencies or deemed savings values.

[450] IECC 2009

Table D-39: Chillers – Baseline Efficiency Levels for Chilled Water Packages[451]

			Path A		Path B	
Equipment Type	***Chiller Type***	***Capacity (Tons)***	***IPLV (kW/TON)***	***EER (kW/Ton)***	***IPLV (kW/TON)***	***EER (kW/Ton)***
Air Cooled	All	<150	0.960	1.255	0.960	1.255
		≥ 150	0.941	1.255	0.941	1.255
Water Cooled	Rotary/ Screw/Scroll/ Reciprocating	< 75	0.630	0.780	0.600	0.800
		≥ 75 and < 150	0.615	0.775	0.586	0.790
		≥ 150 and < 300	0.580	0.680	0.540	0.718
		≥ 300	0.540	0.620	0.490	0.639
Water Cooled	Centrifugal	< 300	0.596	0.634	0.450	0.639
		≥ 300 and < 600	0.549	0.576	0.400	0.600
		≥ 600	0.539	0.570	0.400	0.590

D.3.3.3. Estimated Useful Life (EUL)

For high-efficiency chillers, according to the DEER 2014, the estimated useful life (EUL) is 20 years.

D.3.3.4. Deemed Savings Values

This measure has significant variability in equipment capacity and thus a per-unit savings value is not likely to be usable by program administrators. Due to this we present savings in a per-ton basis, assuming IECC 2009 efficiencies are the baseline, and the proposed efficiencies are 10% better than the federal minimum EER and IPLV values[452,453].

Table D-40: Deemed Savings – Air-Cooled Chillers

Building Type		***Path A***	***Path B***

[451] The values in the table reflect IECC 2009, Table 503.2.3(7).

[452] https://www.energy.gov/eere/femp/purchasing-energy-efficient-air-cooled-electric-chillers

[453] https://www.energy.gov/eere/femp/purchasing-energy-efficient-water-cooled-electric-chillers

	Capacity (Tons)	Energy (kWh/Ton)	Demand (kW/Ton)	Energy (kWh/Ton)	Demand (kW/Ton)
Fast Food	<150	408	0.169	658	0.110
	> 150	403	0.177	642	0.110
Grocery	<150	262	0.195	423	0.127
	> 150	259	0.204	413	0.127
Health Clinic	<150	341	0.184	551	0.120
	> 150	338	0.192	538	0.120
Large Office	<150	255	0.182	411	0.119
	> 150	252	0.190	401	0.119
Lodging	<150	360	0.167	580	0.109
	> 150	356	0.174	566	0.109
Full Menu Restaurant	<150	343	0.184	553	0.120
	> 150	339	0.192	540	0.120
Retail	<150	548	0.191	884	0.125
	> 150	542	0.199	863	0.125
School	<150	400	0.154	645	0.101
	> 150	395	0.161	630	0.101
Small Office	<150	354	0.182	570	0.119
	> 150	350	0.190	557	0.119
University	<150	259	0.182	418	0.119
	> 150	256	0.190	408	0.119

Table D-41: Deemed Savings – Water-Cooled Chillers – Positive Displacement[454]

Building Type	Capacity (Tons)	Path A		Path B	
		Energy (kWh/Ton)	Demand (kW/Ton)	Energy (kWh/Ton)	Demand (kW/Ton)
Fast Food	< 75	214	0.092	356	0.076
	> 75 and < 150	264	0.099	344	0.090
	> 150 and < 300	223	0.073	342	0.083
	> 300	192	0.073	319	0.060
Grocery	< 75	137	0.106	229	0.088
	> 75 and < 150	169	0.114	221	0.104
	> 150 and < 300	143	0.085	220	0.095
	> 300	124	0.084	205	0.069
Health Clinic	< 75	179	0.100	298	0.083
	> 75 and < 150	221	0.108	288	0.098
	> 150 and < 300	187	0.080	286	0.090
	> 300	161	0.079	268	0.065
Large Office	< 75	133	0.099	222	0.082
	> 75 and < 150	165	0.107	215	0.097
	> 150 and < 300	139	0.079	214	0.089
	> 300	120	0.079	199	0.064
Lodging	< 75	189	0.091	314	0.075
	> 75 and < 150	233	0.098	304	0.089
	> 150 and < 300	197	0.072	302	0.082
	> 300	170	0.072	282	0.059
Full Menu Restaurant	< 75	180	0.100	300	0.083
	> 75 and < 150	222	0.108	290	0.098
	> 150 and < 300	188	0.080	288	0.090
	> 300	162	0.079	269	0.065
Retail	< 75	287	0.103	479	0.086
	> 75 and < 150	354	0.112	463	0.101
	> 150 and < 300	300	0.083	460	0.093
	> 300	258	0.082	429	0.067
School	< 75	210	0.083	349	0.070
	> 75 and < 150	259	0.090	338	0.082
	> 150 and < 300	219	0.067	335	0.075
	> 300	189	0.066	313	0.054
Small Office	< 75	185	0.099	309	0.082
	> 75 and < 150	229	0.107	299	0.097
	> 150 and < 300	194	0.079	297	0.089
	> 300	167	0.079	277	0.064
University	< 75	136	0.099	227	0.082
	> 75 and < 150	168	0.107	219	0.097
	> 150 and < 300	142	0.079	217	0.089
	> 300	122	0.079	203	0.064

[454] Rotary/Screw/Scroll/Reciprocating

Table D-42: Deemed Savings – Water-Cooled Chillers – Centrifugal

Building Type	CAP	Path A		Path B	
		Energy (kWh/Ton)	Demand (kW/Ton)	Energy (kWh/Ton)	Demand (kW/Ton)
Fast Food	< 300	240	0.066	171	0.032
	> 300 and < 600	214	0.056	127	0.054
	> 600	211	0.051	138	0.050
Grocery	< 300	154	0.077	110	0.036
	> 300 and < 600	137	0.065	82	0.062
	> 600	136	0.059	89	0.057
Health Clinic	< 300	201	0.072	143	0.034
	> 300 and < 600	179	0.061	106	0.059
	> 600	177	0.056	115	0.054
Large Office	< 300	150	0.071	107	0.034
	> 300 and < 600	133	0.060	79	0.058
	> 600	132	0.055	86	0.053
Lodging	< 300	212	0.065	151	0.031
	> 300 and < 600	189	0.055	112	0.053
	> 600	186	0.051	122	0.049
Full Menu Restaurant	< 300	202	0.072	144	0.034
	> 300 and < 600	180	0.061	107	0.059
	> 600	178	0.056	116	0.054
Retail	< 300	322	0.075	230	0.036
	> 300 and < 600	287	0.063	171	0.061
	> 600	284	0.058	185	0.056
School	< 300	235	0.060	168	0.029
	> 300 and < 600	210	0.051	125	0.049
	> 600	207	0.047	135	0.045
Small Office	< 300	208	0.071	148	0.034
	> 300 and < 600	185	0.060	110	0.058
	> 600	183	0.055	119	0.053
University	< 300	153	0.071	109	0.034
	> 300 and < 600	136	0.060	81	0.058
	> 600	134	0.055	88	0.053

D.3.3.5. Calculation of Deemed Savings

Deemed peak demand and annual energy savings for chillers should be calculated using the following formulas:

$$kW_{Savings} = CAP \times (\eta_{base} - \eta_{post}) \times CF$$

$$kWh_{savings} = CAP \times EFLH_C \times (\eta_{base} - \eta_{post})$$

Where:

CAP = Rated equipment cooling capacity of the new unit (Tons)

η_{base} = Baseline energy efficiency rating of the baseline cooling equipment (kW/ton or EER converted to kW/ton)

η_{post}= Nameplate energy efficiency rating of the installed cooling equipment (kW/ton)

Note: use full-load efficiency (in units of kW/ton) for kW savings calculations and IPLV (in units of kW/ton) for kWh savings calculations. Cooling efficiencies expressed as an EER will need to be converted to kW/ton using the following equation:

$$\frac{kW}{Ton} = \frac{12}{EER}$$

CF= Coincidence factor ()

$EFLH_c$= Equivalent full-load hours for cooling (Table *D-43*)

$EFLH_h$= Equivalent full-load hours for heating (Table *D-44*)

Table D-43: Equivalent Full-Load Hours by Building type

Building Type	$EFLH_C$	$EFLH_H$
Fast Food	2,375	272
Grocery	1,526	153
Health Clinic	1,989	115
Large Office	1,483	392
Lodging	2,095	409
Full Menu Restaurant	1,997	166
Retail	3,191	513
School	2,329	140
Small Office	2,060	255
University	1,510	604

Table D-44: Commercial Coincidence Factors by Building Type

Building Type	***Coincidence Factor***
Fast Food	0.78
Grocery	0.90
Health Clinic	0.85
Large Office	0.84
Lodging	0.77
Full Menu Restaurant	0.85
Retail	0.88
School	0.71
Small Office	0.84
College	0.84

D.3.3.6. Incremental Cost

Incremental cost is detailed in Table *D-45* below.

Table D-45: Chiller Incremental Cost

Equipment Type	***Capacity***	***Cost Per Ton***
Air-cooled	All capacities	$127/ton[455]
Water-cooled – reciprocating	All capacities	$22/ton[456]
Water-cooled – rotary & scroll	< 150 tons	$351/ton[457]
	>=150 and < 300 tons	$127/ton
	>= 300 tons	$87/ton

D.3.3.7. Future Studies

This is a low-volume, high-savings measure. The TPE recommends that chiller projects be flagged for IPMVP Option C or D analysis when they occur.

[455] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008. Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2012 to IECC 2015 carries the same incremental costs. Values should be verified during evaluation

[456] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation"

[457] Incremental costs for water-cooled, positive displacement (rotary screw and scroll) from the W017 Itron California Measure Cost Study, accessed via http://www.energydataweb.com/cpuc/search.aspx. The data is provided in a file named "MCS Results Matrix – Volume I".

D.3.4. Commercial Air Conditioner and Heat Pump Tune-Up

D.3.4.1. Measure Description

This measure applies to central air conditioners and heat pumps. An AC tune-up, in general terms, involves checking, adjusting and resetting the equipment to factory conditions, such that it operates closer to the performance level of a new unit. For this measure, the service technician must complete the following tasks according to industry best practices:

- Inspect and clean condenser, evaporator coils, and blower.
- Inspect refrigerant level and adjust to manufacturer specifications.
- Measure the static pressure across the cooling coil to verify adequate system airflow and adjust to manufacturer specifications.
- Inspect, clean, or change air filters.
- Calibrate thermostat on/off setpoints based on building occupancy.
- Tighten all electrical connections, and measure voltage and current on motors.
- Lubricate all moving parts, including motor and fan bearings.
- Inspect and clean the condensate drain.
- Inspect controls of the system to ensure proper and safe operation. Check the starting cycle of the equipment to assure the system starts, operates, and shuts off properly.
- Provide documentation showing completion of the above checklist to the utility or the utility's representative.

D.3.4.2. Baseline and Efficiency Standards

The baseline is a system with demonstrated imbalances of refrigerant charge.

After the tune-up, the equipment must meet airflow and refrigerant charge requirements. To ensure the greatest savings when conducting tune-up services, the eligibility minimum requirement for airflow is the manufacturer specified design flow rate, or 350 CFM/ton, if unknown. Also, the refrigerant charge must be within +/- 3 degrees of target sub-cooling for units with thermal expansion valves (TXV) and +/- 5 degrees of target super heat for units with fixed orifices or a capillary.

The efficiency standard, or efficiency after the tune-up, is assumed to be the manufacturer specified energy efficiency ratio (EER) of the existing central air conditioner or heat pump. The efficiency improvement resulting from the refrigerant charge adjustment depends on the pre-adjustment refrigerant charge.

D.3.4.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life (EUL) for refrigerant charge correction is 10 years.

D.3.4.1. Deemed Savings Values

This measure has significant variability in equipment capacity and thus a per-unit savings value is not likely to be usable by program administrators. Due to this we present savings in a per-ton basis. Savings assume a 15% efficiency loss.

Table D-46: Deemed Savings by Building Type – Commercial AC Tune-up

Building Type	kWh/Ton	kW/Ton
Fast Food	457	0.1502
Grocery	294	0.1733
Health Clinic	383	0.1636
Large Office	285	0.1617
Lodging	403	0.1482
Full Menu Restaurant	384	0.1636
Retail	614	0.1694
School	448	0.1367
Small Office	397	0.1617
University	291	0.1617
Unknown	396	0.159

Table D-47: Deemed Savings by Building Type – Commercial Heat Pump Tune-up

Building Type	kWh/Ton	kW/Ton
Fast Food	538	0.1529
Grocery	340	0.1765
Health Clinic	420	0.1667
Large Office	395	0.1647
Lodging	519	0.151
Full Menu Restaurant	436	0.1667
Retail	761	0.1725
School	494	0.1392
Small Office	471	0.1647
University	456	0.1647
Unknown	483	0.162

D.3.4.2. Calculation of Deemed Savings

Deemed peak demand and annual energy savings for unitary AC/HP tune-up should be calculated using the following formulas:

$$kW_{savings,C} = CAP_C \times \frac{1\ kW}{1{,}000\ W} \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times CF$$

$$kWh_{savings,C} = CAP_C \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right)$$

$$kWh_{savings,H} = CAP_H \times \frac{1\ kW}{1{,}000\ W} \times EFLH_H \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right)$$

$$kWh_{savings,AC} = kWh_{savings,C}$$

$$kWh_{savings,HP} = kWh_{savings,C} + kWh_{savings,H}$$

Where,

CAP_c= Rated equipment cooling capacity (BTU/hr.)

CAP_h= Rated equipment heating capacity (BTU/hr.)

EER_{pre}= Adjusted efficiency of the equipment for cooling before tune-up (BTU/watt-hr)

EER_{post}= Nameplate efficiency of the existing equipment for cooling; if unknown, use default EER value (BTU/watt-hr) Table D-50 and Table D-51 .

Note: Site measurements may be substituted for EER_{pre} and EER_{post}, providing that the measurements are taken on the same site visit and under similar operating conditions using reliable, industry accepted techniques. If onsite measurements are used to measure savings for measures other than refrigerant charge, then the implementer should use an EUL of three years.

$HSPF_{pre}$ = Efficiency of the equipment for heating before tune-up (BTU/watt-hr)

$HSPF_{post}$ = Nameplate efficiency of the existing equipment for heating; if unknown, use default HSPF value from Table D-52 (BTU/watt-hr)

CF = Coincidence factor (Table D-54)

$EFLH_c$= Equivalent full-load hours for cooling (Table *D-53*)

$EFLH_h$= Equivalent full-load hours for heating (Table *D-53*)

The adjusted EER_{pre} can be calculated using the following equation:

$$EER_{pre} = (1 - EL) * EER_{post}$$

Where,

EL = Efficiency Loss (Fixed Orifice: Table D-48; TXV: Table D-49) determined by averaging reported efficiency losses from multiple studies.[458,459,460,461,462] Interpolation of the efficiency loss values presented is allowed. Extrapolation is not allowed.

Using the COP, HSPF and ERR can be calculated by multiplying the COP by 3.413.

Table D-48: Efficiency Loss Percentage by Refrigerant Charge Level (Fixed Orifice)

% Charged	EL
≤ 70	0.37
75	0.29
80	0.20
85	0.15
90	0.10
95	0.05
100	0.00
≥ 120	0.03

Table D-49: Efficiency Loss Percentage by Refrigerant Charge Level (TXV)

% Charged	EL
≤ 70	0.12
75	0.09
80	0.07
85	0.06
90	0.05
95	0.03
100	0.00
≥ 120	0.04

458 Architectural Energy Corporation, managed by New Buildings Institute. “Small HVAC System Design Guide.” Prepared for the California Energy Commission. October 2003. Figure 11.

459 Davis Energy Group. “HVAC Energy Efficiency Maintenance Study,” California Measurement Advisory Council (CALMAC). December 29, 2010. Figure 14.

460 Proctor Engineering Group. “Innovative Peak Load Reduction Program CheckMe! Commercial and Residential AC Tune-Up Project.” California Energy Commission. November 6, 2003. Table 6-3.

461 Proctor Engineering Group. PEG Tune-Up Calculations spreadsheet.

462 Pennsylvania Technical Reference Manual (TRM). June 2012. Measure 3.3.2, Table 3-96.

Table D-50: Default Air Conditioner EER per Size Category[463]

Size Category (BTU/hr.)	EER (BTU/watt-hr)[464]
11.8	11.8
< 65,000	11.0
≥ 65,000 and < 135,000	10.8
≥ 135,000 and < 240,000	9.8
≥ 240,000 and < 760,000	9.5

Table D-51: Default Heat Pump EER per Size Category[465]

Size Category (BTU/hr.)	EER (BTU/watt-hr)
< 65,000	11.8
≥ 65,000 and < 135,000	10.8
≥ 135,000 and < 240,000	10.4
≥ 240,000	9.3

$$HSPF_{pre} = (HSPF_{post}) \times (1 - M)^{age}$$

Where,

$HSPF_{post}$= HSPF of pre-tune up equipment when new (use nameplate or default value from Table D-52)

M = Maintenance factor[466], use 0.01 if annual maintenance conducted or 0.03 if maintenance is seldom

Age = Age of equipment in years, up to a maximum of 20 years, use a default of 10 years if unknown.

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463 Code specified SEER or EER value from 2013 Addenda to ASHRAE 90.1-2010 (efficiency value effective January 1, 2015 for units < 65,000 Btu/hr and prior to January 1, 2010 for units ≥ 65,000 Btu/hr).

463 Code specified SEER or EER value from ASHRAE 90.1-2010 (efficiency value effective January 1, 2015

464 SEER values converted to EER using EER = -0.02 x $SEER^2$ + 1.12 x SEER. National Renewable Energy Laboratory (NREL). "Building America House Simulation Protocols." U.S. DOE. Revised October 2010. http://www.nrel.gov/docs/fy11osti/49246.pdf.

465 Code specified SEER or EER value from 2013 Addenda to ASHRAE 90.1-2010 (efficiency value effective January 1, 2015 for units < 65,000 Btu/hr and prior to January 1, 2010 for units > 65,000 Btu/hr).

466 "Building America House Simulation Protocols." U.S. DOE. Revised October 2010. Table 32. Page 40. http://www.nrel.gov/docs/fy11osti/49246.pdf.

Table D-52: Default Heat Pump HSPF per Size Category[467]

Size Category (BTU/hr.)	Subcategory or Rating Condition	Default HSPF[468]
< 65,000	Split System	8.2
	Single Package	8.0
≥ 65,000 and < 135,000	47°F db/43°F wb Outdoor Air	11.3
	17°F db/15°F wb Outdoor Air	7.7
≥ 135,000	47°F db/43°F wb Outdoor Air	10.9
	17°F db/15°F wb Outdoor Air	7.0

Table D-53: Equivalent Full-Load Hours by Building Type

Building Type	$EFLH_C$	$EFLH_H$
Fast Food	2,375	272
Grocery	1,526	153
Health Clinic	1,989	115
Large Office	1,483	392
Lodging	2,095	409
Full Menu Restaurant	1,997	166
Retail	3,191	513
School	2,329	140
Small Office	2,060	255
University	1,510	604

Table D-54: Commercial Coincidence Factors by Building Type[469]

Building Type	Coincidence Factor
Fast Food	0.78
Grocery	0.90
Health Clinic	0.85
Large Office	0.84
Lodging	0.77

[467] Code specified HSPF or COP value from 2013 Addenda to ASHRAE 90.1-2010 (efficiency value effective January 1, 2015 for units < 65,000 Btu/hr and prior to January 1, 2010 for units > 65,000 Btu/hr).

[468] COP values converted to HSPF using COP=HSPF÷3.412

[469] Values for Assembly and Religious Worship building types developed using an adjustment factor derived through a comparison of average CFs for College/University and Assembly/Religious Worship building types from the Texas state Technical Reference Manual. College/University was selected as a reference building type due to average alignment with Assembly/Religious worship building types in other TRMs, inclusion of a summer session, and increased evening usage.

Full Menu Restaurant	0.85
Retail	0.88
School	0.71
Small Office	0.84
College	0.84

D.3.4.3. Incremental Cost

Program-actual costs should be used. If not available, use $35/ton[470].

D.3.4.4. Future Studies

The incremental cost value is very sensitive to labor costs, and as such a New Orleans-specific cost study should be conducted to revise this value. Further, due to past realization rate issues with residential AC tune-up, if this offering is expanded to the commercial sector the TPE strongly recommends a whole-program billing analysis to support savings estimates.

[470] Act on Energy Commercial Technical Reference Manual No. 2010-4

D.3.5. Guest Room Energy Management (GREM) Controls

D.3.5.1. Measure Description

Packaged terminal heat pumps (PTHP) and packaged terminal air conditioners (PTAC) are commonly installed in the hospitality industry to provide heating and cooling of individual guest rooms. Occupancy-based PTHP/PTAC controllers are a combination of a control unit and occupancy sensor that operate in conjunction with each other to provide occupancy-controlled heating and/or cooling. The control unit plugs into a wall socket and the PTHP/PTAC plugs into the control unit. The control unit is operated by an occupancy sensor that is mounted in the room and turns the PTHP/PTAC on and off. The most common application for occupancy-based PTHP/PTAC controls is hotel rooms.

To qualify for savings, equipment must have a setback of at least 5 degrees Fahrenheit. Setbacks greater than 8 degrees Fahrenheit are not recommended due to occupant comfort considerations.

D.3.5.2. Baseline and Efficiency Standards

There is no code requirement for installation of GREM systems. The baseline configuration is a PTAC/PTHP with a manually controlled thermostat.

D.3.5.3. Estimated Useful Life (EUL)

The average lifetime of this measure is eight years, in accordance with DEER 2014.

D.3.5.4. Calculation of Deemed Savings

Estimated gross annual energy savings is 355kWh/unit, based on numbers reported by Xcel Energy and scaled appropriately based on New Orleans weather data. There is no peak demand savings associated with this measure. As these savings estimates are based on a single reference, it is recommended that New Orleans work with early program participants to conduct actual pre- and post-measurement of energy use to verify the accuracy of these values.

D.3.5.5. Incremental Cost

The incremental cost is the difference between a GREM system and a manual thermostat, $260[471].

D.3.5.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values from other programs. If this measure is added to Energy Smart programs, the evaluation should include a metering study to support occupancy estimates.

[471] DEER 2014 value for energy management systems

D.3.6. Demand Control Ventilation

D.3.6.1. Measure Description

Commercial Demand Controlled Ventilation (DCV) entails installing CO_2 sensors within occupied zones in a commercial building in order to optimize the amount of outside air supplied to the space. This reduces energy use for space conditioning by reducing the amount of air supplied during unoccupied times. Furthermore, maintaining appropriate airflow can improve occupant health and productivity by ensuring adequate ventilation for pollutant and odor removal, as well as preventing excessive buildup of CO_2[472].

D.3.6.2. Baseline and Efficiency Standards

The baseline for this measure was modeled as a prototypical building for 7 different building types that would most benefit from installing DCV due to their high occupancy density as well as significant variability in occupancy patterns. These models were also modified to calculate separate savings for buildings with Gas heat and Air Conditioning, as well as buildings with Heat Pumps. This measure is also only appropriate for retrofit applications. The efficiency standard for this measure, in accordance with IECC 2009, is that DCV is "*required for spaces larger than 500 ft^2 . . . and with an average occupant load of 40 people per 1000 ft^2 of floor area*". Thus, savings cannot be claimed for new construction in spaces that meet this minimum criterion unless the space is exempt in accordance with the exemptions listed in section 503.2.5[473].

D.3.6.3. Estimated Useful Life (EUL)

The EUL for this product is taken to be the life of a typical CO_2 sensor. This was determined to be 15 years[474].

D.3.6.4. Deemed Savings Values

The deemed savings values were calculated using DEER prototypical commercial building energy models in eQUEST. Occupant densities were modified in accordance with the DOE prototype buildings[475], and the standard airflow rate per person was input as 15 CFM. For the deemed savings values, the DEER Models assumed a minimum

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472 D. P. Wyon. "Indoor Environmental Effects on Productivity." (1996). Johnson Controls Inc. Accessed September 5, 2018 from: 310404371_Indoor_environmental_effects_on_productivity_Proceedings_of_IAQ_1996_Paths_to_better_building_environments

473 IECC 2009 DCV Requirements https://up.codes/viewer/pennsylvania/iecc-2009/chapter/5/commercial-energy-efficiency#503.2.5.1

474 "Datasheet: K-30 Sensor." (2015). Accessed September 5, 2018 from: http://co2meters.com/Documentation/Datasheets/DS30-01%20-%20K30.pdf

475 "Commercial Prototype Building Models." U.S. Department of Energy & Pacific Northwest National Laboratory. Accessed August 27, 2018 from: https://www.energycodes.gov/development/commercial/prototype_models

airflow of 0.40 CFM per ft^2, a COP of 3.5 for cooling and heating, and a furnace efficiency of 82%. These parameters can be found in the table below.

Table D-55: Occupant Density by Building Type

Building Type	Building Zones (ft^2)	Occupant Density (ft^2/Person)	Airflow Requirement (cfm/person)	Notes
Small Office General	Office: 122,500 Conference: 7,000 Restroom: 8,750 Lobby: 7,500 Other: 29,250 Total: 175,000	180	15	
Small Office Densely Filled	Office: 122,500 Conference: 7,000 Restroom: 8,750 Lobby: 7,500 Other: 29,250 Total: 175,000	90		Divided baseline by half
Retail Stand-Alone	Retail: 6,400 Storage: 1,600 Total: 8,000	67		Storage space left at original occupancy density
Primary School (K-6)	Classroom: 31,500 Dining: 7,500 Gym: 7,500 Kitchen: 3,500 Total: 50,000	40		Office/Gym space densities unchanged
Secondary School (7-12)	Classroom: 31,500 Dining: 7,500 Gym: 7,500 Kitchen: 3,500 Total: 50,000	28.5		
Restaurant	Dining: 2,000 Kitchen: 1,200 Lobby: 600, Restroom: 200 Total: 4,000	25		Kitchen and Bathroom density and airflow unchanged
Assembly	Auditorium: 33,235 Office: 765 Total: 34,000	50		DEER Default

Table D-56: Deemed Savings by Building Type – PTAC

Building Type	kWh/Ton	kW/Ton
Small Office General	35.1	-0.0228
Small Office Densely Occupied	68.4	-0.0633
Retail Stand-Alone	135.9	0.0315
Primary School (K-6)	50.0	0.0325
Secondary School (7-12)	48.2	0.0243
Restaurant	128.6	0.0136
Assembly	168.5	0.0323

Table D-57: Deemed Savings by Building Type - PTHP

Building Type	kWh/Ton	kW/Ton

Small Office General	40.8	-0.0229
Small Office Densely Occupied	83.3	-0.0459
Retail Stand-Alone	190.1	0.2313
Primary School (K-6)	86.4	0.0414
Secondary School (7-12)	85.9	0.0301
Restaurant	205.1	0.0129
Assembly	288.0	0.0339

D.3.6.5. Calculation of Deemed Savings

Deemed peak demand and annual energy savings for DCV in systems with Packaged Terminal Air Conditioning (PTAC) and Packaged Terminal Heat Pump (PTHP) should be calculated using the following equations. The energy savings are given as kWh/Ton and the demand savings are given in kW/Ton. This tonnage is the rated capacity of the HVAC equipment serving the DCV space(s) within the applicant's building(s).

$$kW_{Savings,PTAC} = CAP \times \frac{kW}{Ton}$$

$$kW_{Savings,PTHP} = \frac{CAPC + CAPH}{2} \times \frac{kW}{Ton}$$

$$kWh_{Savings,PTAC} = CAP \times \frac{kWh}{Ton}$$

$$kWh_{Savings,PTHP} = \frac{CAPC + CAPH}{2} \times \frac{kWh}{Ton}$$

Where,

CAP = Rated equipment cooling capacity of the AC unit (Ton.)

$CAPC$ = Rated equipment cooling capacity of the heat pump (Ton.)

$CAPH$ = Rated equipment heating capacity of the heat pump (Ton.)

Note: If the equipment's rated capacity is not given in tons, one can use the conversion factors of 12,000 BTU/hr per ton or 3.517 kW per ton.

D.3.6.6. Incremental Cost

The incremental cost for this equipment is $600[476] to $1,200[477] installed cost in retrofits and an incremental cost of CO_2 sensors being $200 - $260 per sensor for new construction.

[476] "Demand Control Ventilation." NJ Green Building Manual. 2011. Accessed September 4, 2018 from http://greenmanual.rutgers.edu/newcommercial/strategies/demandcontrolventilation.pdf

[477] "Demand Control Ventilation." FPL Technical Primer. Accessed September 4, 2018 from https://www.fpl.com/business/pdf/dcv-primer.pdf

D.3.7. Commercial Smart Thermostats

D.3.7.1. Measure Description

This measure consists of replacing a manually operated or programmable thermostat with an ENERGY STAR®-certified[478] smart thermostat. If the thermostat is not ENERGY STAR®-certified, it must have the following features[479]:

1. Automatic scheduling.
2. Occupancy sensing (set “on” as a default).
3. For buildings with a heat pump, smart thermostats must be capable of controlling heat pumps to minimize the use of backup electric resistance heat.
4. Ability to adjust settings remotely via a smart phone or online in the absence of connectivity to the thermostat service provider, retaining the ability for the facility to:
    a. View the room temperature,
    b. View and adjust the set temperature, and
    c. Switch between off, heating and cooling.
5. Have a static temperature accuracy ≤ ± 2.0 °F
6. Have network standby average power consumption of ≤3.0 W average (including all equipment necessary to establish connectivity to the service provider’s cloud, except those that can reasonably be expected to be present in the home, such as Wi-Fi routers and smart phones.)
7. Enter network standby after ≤ 5.0 minutes from user interaction (on device, remote or occupancy detection)
8. The following capabilities may be enabled through the connected thermostat (CT) device, CT service or any combination of the two. The CT product shall maintain these capabilities through subsequent firmware and software changes:
    a. Ability for consumers to set and modify a schedule.
    b. Provide feedback to occupants about the energy impact of their choice of settings.

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[478] ENERGY STAR’s qualified products list for smart thermostats: https://data.energystar.gov/dataset/ENERGY-STAR-Certified-Connected-Thermostats/7p2p-wkbf

[479] ENERGY STAR Smart Thermostat Specification:: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0_0.pdf

c. Provide access to information relevant to their HVAC energy consumption, e.g. HVAC run time.

D.3.7.2. Baseline & Efficiency Standard

For retrofit projects, the baseline is the preexisting thermostat equipment configuration. For new construction projects, program administrators should assume a programmable thermostat as baseline (in accordance with IECC 2009).

D.3.7.3. Estimated Useful Life (EUL)

The effective useful life (EUL) for this measure is 11 years.[480]

D.3.7.4. Calculation of Deemed Savings

Deemed savings are based off of a percent reduction of annual use compared to the equivalent full-load cooling and heating consumption for the facility. Savings are calculated as:

$$kWh\ Savings = Capacity(C) \times \frac{1}{SEER \times 1000} \times EFLH_C \times Savings\%_C + Capacity(H) \times \frac{1}{HSPF \times 1000} \times EFLH_H \times Savings\%_H$$

Where,

Capacity(C) = Cooling capacity (BTU)

SEER = Efficiency of controlled AC. Use current code requirements if nameplate actual is not available.

1000 = unit conversion

EFLH(C) = Equivalent Full Load Cooling Hours. See Table D-58.

Capacity(H) = Heating capacity (BTU)

HSPF = Heating Efficiency of controlled HVAC system. Use current code requirements if nameplate actual is not available.

EFLH(H) = Equivalent Full Load Heating Hours. See Table D-58.

Savings%(C) = Annual percent cooling savings

Savings%(H) = Annual percent heating savings

Capacity should be collected as part of the project application.

Table D-58: Equivalent Full-Load Hours by Building Type

Building Type	$EFLH_C$	$EFLH_H$

[480] DEER 2014 EUL tables

Fast Food	2,375	272
Grocery	1,526	153
Health Clinic	1,989	115
Large Office	1,483	392
Lodging	2,095	409
Full Menu Restaurant	1,997	166
Retail	3,191	513
School	2,329	140
Small Office	2,060	255
University	1,510	604

Table D-59 summarizes the annual percent savings for heating and cooling by baseline thermostat. Savings for natural gas are presented so as to allow program administrators to quantify the full benefit from installation of a smart thermostat in a facility with electric cooling and natural gas space heating.

Table D-59: Savings Percent by Baseline Type

System	Baseline	
	Manual Thermostat[481]	Programmable Thermostat[482]
Electric Cooling	5%	3%
Electric Heating	4%	2%
Natural Gas Heating	5%	2%

D.3.7.5. Sample Calculation

For example, assume a small retail facility using an air source heat pump. The equipment is 60,000 BTU in capacity with efficiencies of 13 SEER and 7.7 HSPF. The associated EFLH values are 3,191 for cooling and 513 for heating. The facility uses a manual thermostat in the baseline configuration. The savings for this project would be:

[481] The savings percentages claimed for manual thermostats include the savings associated with upgrading from manual thermostats to programmable thermostats, which a 2015 MEMD study reported as about 3% savings for gas customers and 2% savings for electric customers. http://www.michigan.gov/documents/mpsc/CI_Programmable_TStats_MEMD_6_15_15_491808_7.pdf

[482] CLEAResult's "Guide to Smart Thermostats" reports the ranges of savings measured in recent residential evaluations, relative to a baseline that blended programmable and manual thermostats: 10–13% for gas savings; 14–18% for electric cooling savings; and 6–13% for electric heating. This finding is extrapolated to commercial facilities in this analysis. savings.https://www.clearesult.com/insights/whitepapers/guide-to-smart-thermostats

$$Cooling\ Savings = 60{,}000 \times \frac{1}{13 \times 1000} \times 3{,}191 \times 5\% = 736\ kWh$$

$$Heating\ Savings = 60{,}000 \times \frac{1}{7.7 \times 1000} \times 513 \times 4\% = 160\ kWh$$

There are too many possible facility and equipment configuration combinations to provide pre-determined deemed savings. Program administrators should follow the algorithm specified above.

D.3.7.6. Incremental Cost

Actual measure cost should be used where available. If not available, the incremental cost of installing a smart thermostat is $154[483] for new construction and $208[484] for retrofit.

D.3.7.7. Future Studies

Current savings estimates for this measure cite existing studies from other climate zones. This measure should receive a detailed impact evaluation once sufficient participation has occurred. The impact evaluation of this measure is recommended to be completed during the 2021 program year, allowing for a full year of post-retrofit billing data to be collected from 2020 program participants.

[483] From NEEP's 2016 Incremental Cost Study: http://www.neep.org/incremental-cost-emerging-technology-0, table 3-13 found range of incremental costs to be $80-195 (with baseline as $54 and using Nest/Ecobee at $249). NEEP's more recent list of home energy management systems products (http://neep.org/initiatives/high-efficiency-products/home-energy-management-systems) shows a straight average of 68 products at $210 for the cost of the smart thermostat, bringing the incremental cost assuming $54 for baseline down to $154.

[484] Ibid.

D.4. Refrigeration

D.4.1. Commercial Variable Refrigerant Flow Systems

D.4.1.1. Measure Description

This measure entails the installation of a variable refrigerant flow (VRF) multi-split heat pump system. There are numerous configurations of VRF systems. This chapter covers the two most common configurations in the market:

- Air-cooled VRF heat pumps; and
- Water-cooled VRF heat pumps.

D.4.1.2. Baseline and Efficiency Standards

The baseline for units that are used in new construction or are replaced on burnout is shown in Table D-33. The format of the baseline table is taken from ASHRAE 90.1-2010 Table 6.8.1J Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps – Minimum Efficiency Requirements. This minimum efficiency requirement is based on applied heat pump baseline from Table 6.8.1B from ASHRAE 90.1-2010 where air-cooled VRF system with electric resistance heating references the baseline of applied heat pump with electric resistance heating and VRF with heat recovery with applied heat pump with all other heating types. However, water-cooled VRF baseline was stipulated in ASHRAE 90.1-2010. The current state building energy code is ASHRAE 90.1-2007 and the minimum baseline for applied heat pump from ASHRAE 90.1-2007 to 90.1-2010 didn't change, therefore the table from ASHRAE 90.1-2010 is applicable with an exception of air-cooled VRF system rated for 17F dry-bulb and 43F wet-bulb temperature which must comply the federal minimum standard[485] for heat pumps, which went into effect January 1, 2010.

[485] 2013 U.S. Code: Title 10, Chapter 2, Subchapter D, Part 431, Subpart F, Table 1 to Page 431.97; Minimum Cooling Efficiency Standards for Air-Conditioning and Heating Equipment

Table D-60: VRF Heat Pump System– Baseline Efficiency Standards

Equipment Type	Cooling Capacity (Btu/h)	Heating Section Type	Sub-Category	Minimum Efficiency
VRF, Air Cooled (Cooling Mode)	< 65,000	All	VRF Multi-split System	13 SEER
	≥65,000 & <135,000	Electric Resistance (or none)	VRF Multi-split System	11.0 EER
			VRF Multi-split System with Heat Recovery	10.8 EER
	≥135,000 & <240,000	Electric Resistance (or none)	VRF Multi-split System	10.6 EER
			VRF Multi-split System with Heat Recovery	10.4 EER
	≥240,000	Electric Resistance (or none)	VRF Multi-split System	9.5 EER
			VRF Multi-split System with Heat Recovery	9.3 EER
VRF, Water Cooled (Cooling Mode)	< 65,000	All	VRF Multi-split system, 86°F entering water	12.0 EER
			VRF Multi-split system with Heat Recovery, 86°F entering water	11.8 EER
	≥65,000 & <135,000	All	VRF Multi-split system, 86°F entering water	12.0 EER
			VRF Multi-split system with Heat Recovery, 86°F entering water	11.8 EER
	≥135,000	All	VRF Multi-split system, 86°F entering water	10.0 EER
			VRF Multi-split system with Heat Recovery, 86°F entering water	9.8 EER
VRF, Air Cooled (Heating Mode)	< 65,000	All	VRF Multi-split system	7.7 HSPF
	≥65,000 & <135,000	All	VRF Multi-split system	3.3 COP
	≥135,000	All	VRF Multi-split system	3.2 COP
VRF, Water Cooled (Heating Mode)	<135,000	All	VRF Multi-split system, 68°F entering water	4.2 COP
	≥135,000	All	VRF Multi-split system, 68°F entering water	3.9 COP

D.4.1.3. Estimated Useful Life (EUL)

The typical VRF system is a type of heat pump and the same 15-year EUL from DEER 2016 for commercial heat pumps applies to this measure.

D.4.1.4. Deemed Savings Values

This measure has significant variability in equipment efficiency based on system type and equipment capacity and thus we present savings on a per-ton basis. The measure efficiency is based on the average unit efficiency of all AHRI-certified VRF units[486] in the US market at three different cooling capacity bins.

The following tables present per-ton deemed savings.

Table D-61: Deemed Savings by Building Type – VRF Air-Cooled Heat Pumps

Building Type	Cooling Capacity (tons)	VRF Multi-split System		VRF Multi-split System with Heat Recovery	
		kWh/Ton	kW/Ton	kWh/Ton	kW/Ton
Fast Food	< 11.25	615	0.1898	415	0.1257
	>=11.25 & < 20.00	240	0.0685	283	0.0845
	>= 20.00	300	0.0935	237	0.0746
Grocery	< 11.25	392	0.2190	264	0.1451
	>=11.25 & < 20.00	152	0.0790	180	0.0975
	>= 20.00	191	0.1078	152	0.0861
Health Clinic	< 11.25	500	0.2068	334	0.1370
	>=11.25 & < 20.00	188	0.0746	227	0.0921
	>= 20.00	245	0.1018	195	0.0813
Large Office	< 11.25	415	0.2044	286	0.1354
	>=11.25 & < 20.00	176	0.0737	198	0.0910
	>= 20.00	200	0.1006	156	0.0804
Lodging	< 11.25	566	0.1873	386	0.1241
	>=11.25 & < 20.00	232	0.0676	266	0.0835
	>= 20.00	274	0.0923	215	0.0737
Full Menu Restaurant	< 11.25	509	0.2068	342	0.1370
	>=11.25 & < 20.00	195	0.0746	232	0.0921
	>= 20.00	249	0.1018	197	0.0813
Retail	< 11.25	847	0.2141	575	0.1419
	>=11.25 & < 20.00	340	0.0773	395	0.0954
	>= 20.00	411	0.1054	324	0.0842
School	< 11.25	586	0.1727	392	0.1145
	>=11.25 & < 20.00	221	0.0623	266	0.0770
	>= 20.00	287	0.0851	228	0.0679
Small Office	< 11.25	536	0.2044	362	0.1354
	>=11.25 & < 20.00	211	0.0737	248	0.0910
	>= 20.00	261	0.1006	206	0.0804
University	< 11.25	450	0.2044	315	0.1354
	>=11.25 & < 20.00	203	0.0737	222	0.0910
	>= 20.00	215	0.1006	167	0.0804
Unknown	< 11.25	541	0.2009	367	0.1332
	>=11.25 & < 20.00	216	0.0725	252	0.0895
	>= 20.00	263	0.0990	208	0.0790

[486] 7,974 certified product information pulled from AHRI database on 7/1/2019; AHRI Directory of Certified Product Performance, https://www.ahridirectory.org/NewSearch?programId=72&searchTypeId=3

Table D-62: Deemed Savings by Building Type – VRF Water Cooled Heat Pump

Building Type	Cooling Capacity (tons)	VRF Multi-split System		VRF Multi-split System with Heat Recovery	
		kWh/Ton	kW/Ton	kWh/Ton	kW/Ton
Fast Food	< 5.42	484	0.1443	N/A	N/A
	>=5.42 & < 11.25	509	0.1552	506	0.1527
	>= 11.25	716	0.2191	751	0.2319
Grocery	< 5.42	307	0.1666	N/A	N/A
	>=5.42 & < 11.25	324	0.1791	322	0.1762
	>= 11.25	456	0.2528	479	0.2676
Health Clinic	< 5.42	387	0.1573	N/A	N/A
	>=5.42 & < 11.25	411	0.1692	407	0.1664
	>= 11.25	579	0.2388	610	0.2528
Large Office	< 5.42	338	0.1554	N/A	N/A
	>=5.42 & < 11.25	347	0.1672	349	0.1645
	>= 11.25	486	0.2360	505	0.2498
Lodging	< 5.42	454	0.1425	N/A	N/A
	>=5.42 & < 11.25	471	0.1532	472	0.1508
	>= 11.25	661	0.2163	690	0.2290
Full Menu Restaurant	< 5.42	396	0.1573	N/A	N/A
	>=5.42 & < 11.25	419	0.1692	416	0.1664
	>= 11.25	591	0.2388	621	0.2528
Retail	< 5.42	674	0.1629	N/A	N/A
	>=5.42 & < 11.25	703	0.1751	702	0.1723
	>= 11.25	988	0.2472	1,033	0.2617
School	< 5.42	454	0.1314	N/A	N/A
	>=5.42 & < 11.25	482	0.1413	477	0.1390
	>= 11.25	679	0.1995	715	0.2111
Small Office	< 5.42	422	0.1554	N/A	N/A
	>=5.42 & < 11.25	444	0.1672	442	0.1645
	>= 11.25	624	0.2360	654	0.2498
University	< 5.42	377	0.1554	N/A	N/A
	>=5.42 & < 11.25	381	0.1672	387	0.1645
	>= 11.25	532	0.2360	548	0.2498
Unknown	< 5.42	429	0.1529	N/A	N/A
	>=5.42 & < 11.25	449	0.1644	448	0.1617
	>= 11.25	631	0.2321	661	0.2456

D.4.1.5. Calculated Deemed Savings

Deemed peak demand and annual energy savings for unitary AC and HP equipment should be calculated as shown below.

$$kW_{Savings} = CAP \times \frac{1\ kW}{1{,}000\ W} \times \left(\frac{1}{\eta_{base,Cooling}} - \frac{1}{\eta_{post,Cooling}}\right) \times CF$$

$$kWh_{Savings} = CAP \times \frac{1\ kW}{1{,}000\ W} \times \left[\left(\frac{EFLH_C}{\eta_{base,Cooling}} + \frac{EFLH_H}{\eta_{base,Heating} \times 3.413}\right) - \left(\frac{EFLH_C}{\eta_{post,Cooling}} + \frac{EFLH_H}{\eta_{post,Heating} \times 3.413}\right)\right]$$

Where,

CAP = Rated equipment cooling capacity of the new unit (BTU/hr)

$\eta_{base,Cooling/Heating}$ = Baseline energy efficiency rating of the cooling/heating equipment (*Table* D-33), EER for cooling and COP for heating

$\eta_{post,Cooling/Heating}$= Nameplate energy efficiency rating of the installed cooling/heating equipment (Table *D-63*), EER for cooling and COP for heating

CF = Coincidence factor (Table *D-37*)

$EFLH_c$ = Equivalent full-load hours for cooling (Table *D-36*)

$EFLH_h$ = Equivalent full-load hours for heating (Table *D-36*)

3.413 = kW to Btu/hr Conversion applied to heating COP to heating EER

Table D-63: Measure Efficiency Assumptions[487]

Equipment Type	Cooling Capacity Category (Btu/h)	Cooling Capacity (Btu/h)	Sub-Category	Average Cooling Efficiency (EER)	Average Heating Efficiency (COP)
VRF, Air Cooled	< 65,000	65,000	All	N/A[488]	N/A[368]
	≥65,000 & <135,000	100,000	VRF Multi-split System	12.5	3.8
			VRF Multi-split System with Heat Recovery	12.6	3.7
	≥135,000 & <240,000	187,500	VRF Multi-split System	11.5	3.6
			VRF Multi-split System with Heat Recovery	11.5	3.5
	≥240,000	240,000	VRF Multi-split System	10.5	3.4
			VRF Multi-split System with Heat Recovery	10	3.3
VRF, Water Cooled	< 65,000	65,000	VRF Multi-split system	14.7	5.2
			VRF Multi-split system with Heat Recovery	N/A[368]	N/A[368]
	≥65,000 & <135,000	100,000	VRF Multi-split system	15	5
			VRF Multi-split system with Heat Recovery	14.9	5.1
	≥135,000	135,000	VRF Multi-split system	13.1	4.9
			VRF Multi-split system with Heat Recovery	12.9	4.8

[487] Average efficiency calculated from AHRI certified products available in US market

[488] Product not available in US in this category

Table D-64: Equivalent Full-Load Hours by Building Type

Building Type	***$EFLH_C$***	***$EFLH_H$***
Fast Food	2,375	272
Grocery	1,526	153
Health Clinic	1,989	115
Large Office	1,483	392
Lodging	2,095	409
Full Menu Restaurant	1,997	166
Retail	3,191	513
School	2,329	140
Small Office	2,060	255
University	1,510	604

Table D-65: Commercial Coincidence Factors by Building Type[489]

Building Type	***Coincidence Factor***
Fast Food	0.78
Grocery	0.90
Health Clinic	0.85
Large Office	0.84
Lodging	0.77
Full Menu Restaurant	0.85
Retail	0.88
School	0.71
Small Office	0.84
University	0.84

D.4.1.6. Incremental Cost

The Incremental cost is $3 per square-foot of conditioned space[490] compared to baseline equipment.

D.4.1.7. Future Studies

VRF systems in certain applications has greater energy savings potential than the deemed savings in this version of TRM. For example, if the facility has vacant space that

[489] Values for Assembly and Religious Worship building types developed using an adjustment factor derived through a comparison of average CFs for College/University and Assembly/Religious Worship building types from the Texas state Technical Reference Manual. College/University was selected as a reference building type due to average alignment with Assembly/Religious worship building types in other TRMs, inclusion of a summer session, and increased evening usage.

[490] CLEAResult 2016. “Utility Program Cost Effectiveness of Variable Refrigerant Flow Systems”. ACEEE Summer Study on Energy Efficiency in Buildings 2016. https://aceee.org/files/proceedings/2016/data/papers/3_345.pdf

is not heated or cooled, the VRF unit will run in part-load which can operate with greater efficiency. Furthermore, if the facility installs more cooling capacity than required, they can increase their energy savings by running the unit on a lower part-load. Some VRF units can provide simultaneous heating and cooling which can improve overall unit efficiency as well. An example of this application is to install VRF systems in lodging facilities where not all rooms are occupied so the unit will run on part load, as well as having some rooms request heating while other rooms request cooling. Both operational patterns present an opportunity for a VRF system to achieve greater savings. However, this version of TRM does not cover applications such as this as further is needed. It is advised that in large scale projects, program administrators should consider taking a custom savings approach rather than using this deemed savings approach to capture full potential savings.

D.4.2. Door Heater Controls for Refrigerators and Freezers

D.4.2.1. Measure Description

This measure refers to the installation of anti-sweat door heater controls on glass doors for reach-in commercial refrigerators and freezers. The added control reduces both heater operation time and cooling load.

This measure only qualifies for retrofit applications. New construction applications are not allowed as this measure is standard practice for new construction and comes integrated on most modern glass-door refrigerators and freezers.

D.4.2.2. Baseline and Efficiency Standards

Qualifying equipment includes any controls that reduce the run time of door and frame heaters for refrigerated cases. The baseline efficiency case is a cooler or freezer door heater that operates 8,760 hours per year without any controls. The high efficiency case is a cooler (medium temperature) or freezer (low temperature) door heater connected to a heater control system. There are no state or federal codes or standards that govern the eligibility of equipment.

D.4.2.3. Estimated Useful Life (EUL)

The estimated useful life (EUL) is 12 years as defined in the DEER database.[491]

D.4.2.4. Calculation of Deemed Savings

D.4.2.4.1. Energy Savings

A door heater controller senses dew point (DP) temperature in the store and modulates power supplied to the heaters accordingly. DP inside a building is primarily dependent on the moisture content of outdoor ambient air. Because the outdoor DP varies between weather zones, weather data from each weather zone must be analyzed to obtain a DP profile.

Indoor dew point (t_{d-in}) is related to outdoor dew point (t_{d-out}) according to the following equation. Indoor dew point was calculated at each location for every hour in the year.[492]

$$t_{d-in} = 0.005379 \times t_{d-out}^2 + 0.171795 \times t_{d-out} + 19.870006$$

In the base case, the door heaters are all on and have a duty of 100% irrespective of the indoor DP temperature. For the post-retrofit case, the duty for each hourly reading was calculated by assuming a linear relationship between indoor DP and duty cycle for each bin reading. It is assumed that the door heaters will be all off (duty cycle of 0%) at 42.89°F

[491] California's Database for Energy Efficiency Resources (DEER 2014).

[492] Work Paper PGEREF108: Anti-Sweat Heat (ASH) Controls. Pacific Gas & Electric Company. May 29, 2009.

or lower DP and all on (duty cycle of 100%) at 52.87°F or higher DP for a typical supermarket. Between these values, the door heaters' duty cycle changes proportionally:

$$Door\ Heater\ ON\% = \frac{t_{d-in} - All\ OFF\ Setpt\ (42.89°F)}{All\ ON\ Setpt\ (52.87°F) - All\ OFF\ Setpt\ (42.89°F)}$$

Because the controller only changes the run-time of the heaters, instantaneous door heater power (kW_{ASH}) as a resistive load remains constant per linear foot of door heater at:

$$kW_{ASH} = \frac{kW}{ft} \times L_{DH}$$

Where kW/ft. = 0.0368 for medium temperature and 0.0780 for low temperature applications.

Door heater energy consumption for each hour of the year is a product of power and run-time:

$$kWh_{ASH-Hourly} = kW_{Ash} \times Door\ Heater\ ON\% \times 1\ hour$$

Total annual door heater energy consumption $\left(kWh_{ASH}\right)$ is the sum of all hourly reading values:

$$kWh_{ASH} = \sum kWh_{ASH-Hourly}$$

Energy savings were also estimated for reduced refrigeration loads using average system efficiency and assuming that 35% of the anti-sweat heat becomes a load on the refrigeration system.[493] The cooling load contribution from door heaters can be given by:

$$Q_{ASH}(ton) = 0.35 \times kW_{ASH} \times \frac{3{,}412\ \frac{Btu/h}{ton}}{12{,}000\ \frac{Btu/h}{ton}} \times Door\ Heater\ ON\%$$

The compressor power requirements are based on calculated cooling load and energy-efficiency ratios obtained from the manufacturers' data. The compressor analysis is limited to the cooling load imposed by the door heaters, not the total cooling load of the refrigeration system.

[493] Southern California Edison (SCE), 1999,*"A Study of Energy Efficient Solutions for Anti-Sweat Heaters."* Prepared for the Refrigeration Technology and Test Center (RTTC). December 14. https://www.sce.com/NR/rdonlyres/B1F7A3B4-719D-4CBB-87EB-E27F7CE7ECE0/0/Anti_Sweat_Heater_Report.pdf.

The typical efficiency for a medium temperature case is 9 EER (1.33 kW/ton), and the typical efficiency for a low temperature case is 5 EER (2.40 kW/ton).[494]

Energy used by the compressor to remove heat imposed by the door heaters for each hourly reading is determined based on calculated cooling load and EER, as outlined below:

$$kWh_{Refrig-Hourly} = Q_{ASH} \times \frac{kW}{ton} \times 1\ hour$$

Total annual refrigeration energy consumption is the sum of all hourly reading values:

$$kWh_{Refrig} = \sum kWh_{Refrig-Hourly}$$

Total annual energy consumption (direct door heaters and indirect refrigeration) is the sum of all hourly reading values:

$$kWh_{Total} = kWh_{Refrig} + kWh_{ASH}$$

Once the annual energy consumption (direct door heaters and indirect refrigeration) has been determined for the baseline and post-retrofit case, the total energy savings are calculated by the following equation:

$$Annual\ Energy\ Savings = \Delta kWh = kWh_{Total-Baseline} - kWh_{Total-Post\ Retrofit}$$

D.4.2.4.2. Demand Savings

It is important to note that while there might be instantaneous demand savings as a result of the cycling of the door heaters, peak demand savings will only be due to the reduced refrigeration load. Peak demand savings was calculated by the equation shown below:

$$Peak\ Demand\ Savings = \Delta kW = \frac{kWh_{Refrig-Baseline} - kWh_{Refrig-Post\ Retrofit}}{8{,}760\ hr/yr}$$

D.4.2.5. Deemed Savings Values

Annual and peak energy savings due to anti-sweat door heater controls in medium and low temperature refrigerated cases for New Orleans. Deemed savings is calculated using a ratio compared to El Dorado, AR (Zone 6) Savings provided in the table are per linear foot of glass door-controlled heater.

[494] Chapter 15 of the 2010 ASHRAE Handbook for Refrigeration

Table D-66: Anti-Sweat Heater Controls – Savings per Linear Foot of Case by Location

Weather Zone	Med-Temperature		Low-Temperature	
	Annual kWh/ft. Savings	kW/ft. Savings	Annual kWh/ft. Savings	kW/ft. Savings
New Orleans (Zone 3)	248	0.0046	259	0.0060

D.4.2.6. Incremental Cost

The full installed cost should be used for this measure. If not available, use $300 per circuit[495].

D.4.2.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure had low participation in Energy Smart programs. As a result, savings are calculated using weather-adjusted default values from other programs. If participation exceeds 500,000 kWh, the evaluation should include a metering study to support runtime estimates.

[495] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

D.4.3. Solid Door Refrigerators and Freezers

D.4.3.1. Measure Description

Commercial refrigerators and freezers are commonly found in restaurants and other food service industries. Reach-in, solid-door refrigerators and freezers are significantly more efficient than regular refrigerators and freezers due to better insulation and higher-efficiency components. These efficiency levels relate the volume of the appliance to its daily energy consumption.

D.4.3.2. Baseline and Efficiency Standards

Effective January 1, 2010, EPAct 2005 established new federal minimum efficiency levels for solid-door refrigerators and freezers (see Table D-67 below). Also included are the minimum efficiency levels for the ENERGY STAR® specifications.

Table D-67: Solid-Door Refrigerators and Freezers – Efficiency Levels

Equipment Type	Efficiency Level	Maximum Daily Energy Consumption[496] (kWh/day)
Refrigerator	Baseline	0.1V + 2.04
Refrigerator	ENERGY STAR®	0<V<15, 0.089V + 1.411
		15≤V<30, 0.037V + 2.2
		30≤V<50, 0.056V + 1.635
		50≤V, 0.060V + 1.416
Freezer	Baseline	0.4V + 1.38
Freezer	ENERGY STAR®	0<V<15, 0.250V + 1.250
		15≤V<30, 0.037V + 2.2
		30≤V<50, 0.163V
		50≤V, 0.158V + 6.333

The standard refrigerator/freezer efficiency is based on Table D-67 which contains the baseline annual energy consumption, and demand, for solid-door refrigerators and freezers.

[496] V is the volume of the refrigerator or freezer in cubic feet.

Table D-68: Solid-Door Refrigerators and Freezers – Baseline Measure Information

Type	Size Range[497] (Cubic Ft)	Annual Energy Consumption (kWh/unit)	Demand (kW/unit)
Refrigerator	0-15	1,292	0.15
	15-30	1,840	0.21
	30-50	2,570	0.29
	≥50	3,300	0.38
Freezer	0-15	2,694	0.31
	15-30	4,884	0.56
	30-50	7,804	0.89
	≥50	10,724	1.22

To qualify for this measure, new solid-door refrigerators and freezers must meet ENERGY STAR® minimum efficiency requirements. Table D-69 summarizes the estimated performance information for qualifying units.

Table D-69: Solid-Door Refrigerators and Freezers – Qualifying Measure Information

Type	Size Range[498] (Cubic Ft)	Annual Energy Consumption (kWh/unit)	Demand (kW/unit)
Refrigerator	0-15	1,002	0.114
	15-30	1,208	0.138
	30-50	1,619	0.185
	≥50	2,050	0.234
Freezer	0-15	1,825	0.208
	15-30	4,015	0.458
	30-50	5,210	0.595
	≥50	6,348	0.725

D.4.3.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life (EUL) is 12 years.

D.4.3.4. Deemed Savings Values

Deemed measure savings for qualifying solid-door refrigerators and freezers are presented in Table D-70.

[497] Solid-door refrigerators and freezers were evaluated for four different sizes or volumes (V), 15, 30, 50 and 70 cubic feet. The unit will be operated for 365 days per year.

[498] Ibid.

Table D-70: Solid-Door Refrigerators and Freezers – Deemed Savings Values

Type	Size Range[499] (Cubic Ft)	Annual Energy Consumption (kWh/unit)	Demand (kW/unit)
Refrigerator	0-15	290	0.03
	15-30	631	0.07
	30-50	951	0.11
	≥50	1,250	0.14
Freezer	0-15	869	0.10
	15-30	869	0.10
	30-50	2,593	0.30
	≥50	4,375	0.50

D.4.3.5. Measure Technology Review

Five primary resources contained data about solid-door refrigerators and freezers. The ENERGY STAR® website and the Consortium for Energy Efficiency (CEE) had the same maximum daily energy consumption levels for commercial food-grade refrigerators and freezers. The NPCC report and Ecotope studies gave savings and cost estimates but did not include the volume of the appliances. NYSERDA's deemed savings and cost database (Nexant 2005) contained data for both refrigerators and freezers at common sizes.

Table D-71: Solid-Door Refrigerators and Freezers – Review of Measure Information

Available Resource	Notes
PG&E 2005[41]	Energy savings and cost estimates for refrigerators and freezers at common sizes
DEER 2014[65]	Energy savings and cost estimates for refrigerators and freezers at common sizes
KEMA 2010[24]	Energy savings and cost estimates for refrigerators and freezers at common sizes
CEE[64]	Maximum daily energy consumption levels (kWh/day) for CEE-qualified commercial qualified food-grade refrigerators and freezers
ENERGY STAR®[69]	Maximum daily energy consumption levels (kWh/day) for commercial qualified food-grade refrigerators and freezers
NEXANT 2005[31]	Energy savings and cost estimates for refrigerators and freezers at common sizes
PacifiCorp 2009[44]	Unitary savings included in comprehensive potential study

Note: Italic numbers are endnotes not footnotes. (See Section 4.4 Commercial Measure Reference)

[499] Solid-door refrigerators and freezers were evaluated for four different sizes or volumes (V), 15, 30, 50 and 70 cubic feet. The unit will be operated for 365 days per year.

D.4.3.6. Incremental Cost

The incremental cost is provided in Table D-72[500].

Table D-72: Solid-Door Refrigerators and Freezers Incremental Costs

Type	Incremental Cost
Refrigerator	$143
	$164
	$164
	$249
Freezer	$142
	$166
	$166
	$407

D.4.3.7. Future Studies

This measure applies known values from ENERGY STAR; the TPE does not recommend focused study for this measure. Parameters should be updated to correspond to the most recent ENERGY STAR specification.

[500] For the purposes of this characterization, assume and incremental cost adder of 5% on the full unit costs presented in Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.

D.4.4. Refrigerated Case Night Covers

D.4.4.1. Measure Description

This measure applies to the installation of night covers on otherwise open vertical (multi-deck) and horizontal (coffin-type) low-temperature (L) and medium temperature (M) display cases to decrease cooling load of the case during the night. It is recommended that these film-type covers have small, perforated holes to decrease the build-up of moisture.

Cases may be either: Self Contained (SC) having both evaporator and condenser coils, along with the compressor as part of the unit or Remote Condensing (RC) where the condensing unit and compressor are remotely located. Refrigerated case categories[501] are as follows:

- Vertical Open (VO): Equipment without doors and an air-curtain angle ≥ 0° and < 10°
- Semi-vertical Open (SVO): Equipment without doors and an air-curtain angle ≥ 10° and < 80°
- Horizontal Open (HO): Equipment without doors and an air-curtain angle ≥ 80°

This measure is only eligible for retrofit applications. The measure is standard practice in new construction.

D.4.4.2. Baseline and Efficiency Standards

The baseline standard for this measure is an open low-temperature or medium temperature refrigerated display case (vertical or horizontal) that is not equipped with a night cover.

The efficiency standard for this measure is any suitable material sold as a night cover. The cover must be applied for a period of at least six hours per night.

D.4.4.3. Estimated Useful Life (EUL)

According to the California Database of Energy Efficiency Resources (DEER 2014), strip curtains are assigned an EUL of 4 years.

D.4.4.4. Calculation of Deemed Savings

The following outlines the assumptions and approach used to estimate demand and energy savings due to installation of night covers on open low- and medium-temperature, vertical and horizontal, display cases. Heat transfer components of the display case include infiltration (convection), transmission (conduction), and radiation. This deemed

[501] U.S. DOE, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial Industrial Equipment, Commercial Refrigeration Equipment, Washington DC, p3-15

savings approach assumes that installing night covers on open display cases will only reduce the infiltration load on the case. Infiltration affects cooling load in the following ways:

- Infiltration accounts for approximately 80% of the total cooling load of open vertical (or multi-deck) display cases.[502]
- Infiltration accounts for approximately 24% of the total cooling load of open horizontal (coffin or tub style) display cases.[503]

Installing night covers for a period of 6 hours per night can reduce the cooling load due to infiltration. This was modeled by the U.S. Department of Energy (DOE) for Vertical and Semi-vertical cases.

Table D-73: Vertical & Semi-vertical Refrigerated Case Savings

Case Type[504]	***VO.RC.M***	***VO.RC.L***	***VO.SC.M***	***SVO.RC.M***	***SVO.SC.M***
kWh per day- before Night Curtain	50.52	118.44	38.98	38.48	32.82
kWh per day - with Night Curtain	46.84	111.58	36.99	35.74	31.05
Percent kWh Savings per Day	7%	6%	5%	7%	5%
Annual kWh Savings	1,343	2,504	726	1,000	646
Test Case Length (ft.)	12	12	4	12	4

Table D-74: Horizontal Refrigerated Case Savings

Case Type[505]	***HO.RC.M***	***HO.RC.L***	***HO.SC.M***	***HO.SC.L***

502 ASHRAE 2006. Refrigeration Handbook. Retail Food Store Refrigeration and Equipment. Atlanta, Georgia. pp. 46.1, 46.5, 46.10.

503 Ibid.

504 U.S. DOE, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial Industrial Equipment, Commercial Refrigeration Equipment, Washington DC, pp.5-43- 5-47, 5A-5, 5A-6

505 U.S. DOE, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial Industrial Equipment, Commercial Refrigeration Equipment, Washington DC, pp. 5-48 - 5-51. The level AD3 was used for the baseline efficiency.

kWh per day- before Night Curtain[506]	15.44	34.23	16.06	35.02
kWh per day - with Night Curtain	14.05	31.15	14.61	31.87
Percent kWh Savings per Day[507]	9%	9%	9%	9%
Annual kWh Savings	507	1,124	528	1,150
Test Case Length (ft.)	12	12	4	4

While the DOE also modeled the energy consumption for horizontal open cases, there was not an efficient case modeled with a night cover. The 9% energy savings as found by Faramarzi & Woodworth-Szleper[6] was used to determine the post kWh per day.

D.4.4.5. Deemed Savings Values

Due to the relatively consistent summer dry-bulb temperature across the New Orleans weather zone, deemed savings values are only provided for the average dry-bulb temperature of 96°F.

[506] Ibid.

[507] ASHRAE 1999 Effects of Low-E Shields on the Performance and Power Use of a Refrigerated Display Case. Faramarzi & Woodworth-Szleper, p.8

Table D-75: Refrigerated Case Night Covers – Deemed Savings Values (per Linear Foot)[508]

Case Description	Temperature Range (°F)	kWh Savings (kWh/ft.)	kW Savings (kW/ft.)
Vertical Open, Remote Condensing Medium Temperature	10 – 35 °F	112	0.00
Vertical Open, Remote Condensing Low Temperature	< 10 °F	209	0.00
Vertical Open, Self-Contained Medium Temperature	10 – 35 °F	182	0.00
Semi-vertical Open, Remote Condensing Medium Temperature	10 – 35 °F	83	0.00
Semi-vertical Open, Self-Contained Medium Temperature	10 – 35 °F	162	0.00
Horizontal Open, Remote Condensing Medium Temperature	10 – 35 °F	42	0.00
Horizontal Open, Remote Condensing Low Temperature	< 10 °F	94	0.00
Horizontal Open, Self-Contained Medium Temperature	10 – 35 °F	132	0.00
Horizontal Open, Self-Contained Low Temperature	< 10 °F	288	0.00

[508] Pacific Gas & Electric (PG&E), 2009, "Night Covers for Open Vertical and Horizontal Display Cases (Low and Medium Temperature Cases), May 29,.

Table D-76: Refrigerated Case Night Covers – Deemed Savings Values (per Night Cover)[509]

Case Description	Temperature Range (°F)	Length (ft.)	kWh Savings (kWh/Cover	kW Savings (kW/Cover)
Vertical Open, Remote Condensing Medium Temperature	10 – 35 °F	12	1,344	0.00
Vertical Open, Remote Condensing Low Temperature	< 10 °F	12	2,508	0.00
Vertical Open, Self-Contained Medium Temperature	10 – 35 °F	4	728	0.00
Semi-vertical Open, Remote Condensing Medium Temperature	10 – 35 °F	12	996	0.00
Semi-vertical Open, Self-Contained Medium Temperature	10 – 35 °F	4	648	0.00
Horizontal Open, Remote Condensing Medium Temperature	10 – 35 °F	12	504	0.00
Horizontal Open, Remote Condensing Low Temperature	< 10 °F	12	1,128	0.00
Horizontal Open, Self-Contained Medium Temperature	10 – 35 °F	4	528	0.00
Horizontal Open, Self-Contained Low Temperature	< 10 °F	4	1,152	0.00

D.4.4.1. Incremental Cost

The full measure cost should be used. When not available, use $42 per linear foot (CA DEER 2014). For projects that lack size information, use:

- Remote Condensing: $504
- Self-contained: $168
- Unknown: $336

D.4.4.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure had low participation in Energy Smart programs. As a result, savings are calculated using weather-adjusted default values from other programs. If participation exceeds 500,000 kWh, the evaluation should include a metering study to support coverage time estimates.

[509] Pacific Gas & Electric (PG&E), 2009, "Night Covers for Open Vertical and Horizontal Display Cases (Low and Medium Temperature Cases), May 29,.

D.4.5. Strip Curtains

D.4.5.1. Measure Description

This measure applies to the installation of strip curtains on walk-in coolers and freezers. This reduces the load on the refrigeration system through reduced infiltration of warm ambient air into the walk-in unit. This measure is only eligible for retrofit applications. The measure is standard practice in new construction.

D.4.5.2. Baseline and Efficiency Standards

The baseline standard for this measure is a walk-in cooler or freezer with no preexisting strip curtains or damaged strip curtains.

D.4.5.3. Estimated Useful Life (EUL)

According to the California Database of Energy Efficiency Resources (DEER 2014), refrigerated case night covers are assigned an EUL of 5 years.

D.4.5.4. Calculation of Deemed Savings

Calculation of savings from strip curtains is based on Tamm's equation[510] and the ASHRAE handbook[511].

The formula or savings from strip curtains is as follows:

$$\frac{kWh\ Savings}{ft.^2} = \frac{365 \times t_{open} \times (Eff_{new} - E_{old}) \times 20 \times CD \times A \times \left\{\left[\frac{(T_i - T_r)}{T_i}\right] \times g \times h\right\}^{0.5} \times [p_i \times h_i - p_r \times h_r]}{3{,}412\,\frac{BTU}{kWh} \times COP_{adj} \times A}$$

The parameters are defined in the tables below. Infiltration accounts for approximately 80% of the total cooling load of open vertical (or multi-deck) display cases.[512] Table D-77 summarizes assumptions that are universal across facility types. Table D-78 through Table D-81 summarize assumptions for specific facilities.

Table D-77: Strip Curtain Universal Input Assumptions

Parameter	Unit	Value	Source
kWh savings / ft.^{2}	kWh savings / ft.^{2}	Calculated	Calculated
kW savings / ft.^{2}	kW savings / ft.^{2}	Calculated	Calculated
20: product of 60 seconds and integration factor of 1/3	Seconds/minute	20	Tamms equation
g, gravitational constant	ft./seconds^2	32.174	Physics constant
1073,412	BTU/kWh	3,412	Physics constant

[510] Kalterveluste durch kuhlraumoffnungen. Tamm W,. Kaltetechnik-Klimatisierung 1966;18;142-144

[511] ASHRAE 2010. ASHRAE Handbook, Refrigeration: 13.4, 13.6

[512] ASHRAE 2006. Refrigeration Handbook. Retail Food Store Refrigeration and Equipment. Pp. 46.1, 46.5, 46.10.

Table D-78: Strip Curtain Input Assumptions for Supermarkets

Parameter	Unit	Value		Source
		Coolers	Freezers	
Eff-new: efficacy for new strip curtain.	% of infiltration blocked	.88	.88	http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf
Eff-old: efficacy for preexisting condition	% of infiltration blocked	Old curtain: .58 No curtain: .00 Unknown: .34	Old curtain: .58 No curtain: .00 Unknown: .30	
CD: Discharge Coefficient, an empirically determined scale factor that accounts for difference in infiltration rates predicted by Bernoulli's law and actual observed rates	None	.336	.415	
t-open, minutes walk-in door is open per day	Minutes/day	132	102	
A, doorway area	$ft.^2$	35	35	
H, doorway height	ft.	7	7	
T_i Dry-bulb temp. of infiltrating air	Deg. F	71	67	
T_i Dry-bulb temp. of refrigerated air	Deg. F	37	5	
COP_{adj}, Coefficient of performance of refrigerators and freezers	Unitless ratio	3.07	1.95	
P, Density of infiltration air at 55% relative humidity	$lb./ft.^2$	.074	.074	Psychometric equations based on dry bulb and relative humidity
h, Enthalpy of infiltration air at 55% relative humidity	$BTU/ft.^2$	26.935	24.678	
p_r Density of refrigerated air at 80% relative humidity	$lb./ft.^2$	.079	.085	
h_r Enthalpy of refrigerated air at 80% relative humidity	$BTU/ft.^2$	12.933	2.081	

Table D-79: Strip Curtain Input Assumptions for Convenience Stores

Parameter	Unit	Value		Source
		Coolers	Freezers	

Eff-new: efficacy for new strip curtain.	% of infiltration blocked	.79	.83	http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf
Eff-old: efficacy for preexisting condition	% of infiltration blocked	Old curtain: .58 No curtain: .00 Unknown: .34	Old curtain: .58 No curtain: .00 Unknown: .30	
CD: Discharge Coefficient, an empirically determined scale factor that accounts for difference in infiltration rates predicted by Bernoulli's law and actual observed rates	None	.348	.421	
t-open, minutes walk-in door is open per day	Minutes/day	38	9	
A, doorway area	$ft.^2$	21	21	
H, doorway height	ft.	7	7	
T_i Dry-bulb temp. of infiltrating air	Deg. F	68	64	
T_i Dry-bulb temp. of refrigerated air	Deg. F	39	5	
COP_{adj}, Coefficient of performance of refrigerators and freezers	Unitless ratio	3.07	1.95	
P, Density of infiltration air at 55% relative humidity	$lb./ft.^2$	.074	.074	Psychometric equations based on dry bulb and relative humidity
h, Enthalpy of infiltration air at 55% relative humidity	$BTU/ft.^2$	25.227	23.087	
p_r Density of refrigerated air at 80% relative humidity	$lb./ft.^2$	.079	.085	
h_r Enthalpy of refrigerated air at 80% relative humidity	$BTU/ft.^2$	13.750	2.081	

Table D-80: Strip Curtain Input Assumptions for Restaurants

Parameter	Unit	Value		Source
		Coolers	Freezers	
Eff-new: efficacy for new strip curtain.	% of infiltration blocked	.80	.81	http://www.calmac.org/publications/ComFac_Evaluat

Eff-old: efficacy for preexisting condition	% of infiltration blocked	Old curtain: .58 No curtain: .00 Unknown: .33	Old curtain: .58 No curtain: .00 Unknown: .26	ion_V1_Final_Report_02-18-2010.pdf
CD: Discharge Coefficient, an empirically determined scale factor that accounts for difference in infiltration rates predicted by Bernoulli's law and actual observed rates	None	.383	.442	
t-open, minutes walk-in door is open per day	Minutes/day	45	38	
A, doorway area	$ft.^2$	21	21	
H, doorway height	ft.	7	7	
T_i Dry-bulb temp. of infiltrating air	Deg. F	70	67	
T_i Dry-bulb temp. of refrigerated air	Deg. F	39	8	
COP_{adj}, Coefficient of performance of refrigerators and freezers	Unitless ratio	3.07	1.95	
P, Density of infiltration air at 55% relative humidity	$lb./ft.^2$	.074	.074	Psychometric equations based on dry bulb and relative humidity
h, Enthalpy of infiltration air at 55% relative humidity	$BTU/ft.^2$	26.356	24.678	
p_r Density of refrigerated air at 80% relative humidity	$lb./ft.^2$	.079	.085	
h_r Enthalpy of refrigerated air at 80% relative humidity	$BTU/ft.^2$	13.750	2.948	

Table D-81: Strip Curtain Input Assumptions for Refrigerated Warehouses

Parameter	***Unit***	***Value***	***Source***
Eff-new: efficacy for new strip curtain.	% of infiltration blocked	.80	http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf
Eff-old: efficacy for preexisting condition	% of infiltration blocked	Old curtain: .58 No curtain: .00 Unknown: .54	
CD: Discharge Coefficient, an empirically determined scale factor that accounts for difference in infiltration rates predicted by Bernoulli's law and actual observed rates	None	.425	
t-open, minutes walk-in door is open per day	Minutes/day	494	
A, doorway area	$ft.^2$	80	
H, doorway height	ft.	10	
T_i Dry-bulb temp. of infiltrating air	Deg. F	59	
T_i Dry-bulb temp. of refrigerated air	Deg. F	28	
COP_{adj}, Coefficient of performance of refrigerators and freezers	Unitless ratio	1.91	
P, Density of infiltration air at 55% relative humidity	$lb./ft.^2$	.076	Psychometric equations based on dry bulb and relative humidity
h, Enthalpy of infiltration air at 55% relative humidity	$BTU/ft.^2$	20.609	
p_r Density of refrigerated air at 80% relative humidity	$lb./ft.^2$	.081	
h_r Enthalpy of refrigerated air at 80% relative humidity	$BTU/ft.^2$	9.462	

D.4.5.5. Deemed Savings Values

Table D-82 summarizes savings by system, baseline, and facility type for strip curtains on a per-square-foot basis.

Table D-82: Strip Curtains – Deemed Savings Values (per Square Foot)[513]

Case Description	**Preexisting Curtains**	**kWh Savings (kWh/ft.^{2})**	**kW Savings (kWh/ft.^{2})**
Supermarket – Cooler	Yes	62	0.00708
Supermarket – Cooler	No	108	0.01233
Supermarket – Cooler	Unknown	37	0.00422
Supermarket – Freezer	Yes	179	0.02043
Supermarket – Freezer	No	349	0.03984
Supermarket – Freezer	Unknown	61	0.00696
Convenience Store - Cooler	Yes	5	0.00057
Convenience Store - Cooler	No	20	0.00228
Convenience Store - Cooler	Unknown	11	0.00126
Convenience Store - Freezer	Yes	8	0.00091
Convenience Store - Freezer	No	27	0.00308
Convenience Store - Freezer	Unknown	17	0.00194
Restaurant - Cooler	Yes	8	0.00091
Restaurant – Cooler	No	30	0.00342
Restaurant – Cooler	Unknown	18	0.00205
Restaurant - Freezer	Yes	34	0.00388
Restaurant - Freezer	No	119	0.01358
Restaurant - Freezer	Unknown	81	0.00925
Refrigerated Warehouse	Yes	254	0.02900
Refrigerated Warehouse	No	729	0.08322
Refrigerated Warehouse	Unknown	287	0.03276

Table D-83 summarizes the deemed savings that should be used when project-specific data is not available. These values are per-walk-in door and assume the following:

- Doorway area:
  - Supermarket: 35
  - Convenience Store: 21
  - Restaurant: 21
  - Refrigerated Warehouse: 80
- Preexisting curtains: Unknown

[513] Pacific Gas & Electric (PG&E), 2009, “Night Covers for Open Vertical and Horizontal Display Cases (Low and Medium Temperature Cases), May 29,.

Table D-83: Strip Curtains – Deemed Savings Values (per Square Foot)[514]

Case Description	Preexisting Curtains	kWh Savings (kWh/door)	kW Savings (kW/door)
Supermarket – Cooler	Unknown	1,295	0.1477
Supermarket – Freezer	Unknown	2,135	0.2436
Convenience Store - Cooler	Unknown	231	0.02646
Convenience Store - Freezer	Unknown	357	0.04074
Restaurant – Cooler	Unknown	378	0.04305
Restaurant - Freezer	Unknown	1,701	0.19425
Refrigerated Warehouse	Unknown	22,960	2.6208

D.4.5.6. Incremental Cost

The full measure cost should be used. When not available, use $10.22 per linear foot (CA DEER 2014).

For projects that lack specific inputs for size, the default incremental costs are:

- Supermarket: $358
- Convenience Store: $215
- Restaurant: $215
- Refrigerated Warehouse: $818

D.4.5.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure had low participation in Energy Smart programs. As a result, savings are calculated using weather-adjusted default values from other programs. If participation exceeds 500,000 kWh, the evaluation should include a metering study to support coverage time estimates.

[514] Pacific Gas & Electric (PG&E), 2009, "Night Covers for Open Vertical and Horizontal Display Cases (Low and Medium Temperature Cases), May 29,.

D.4.6. Zero Energy Doors

D.4.6.1. Measure Description

This measure applies to the installation of zero energy doors for refrigerated cases. Zero energy doors eliminate the need for anti-sweat heaters to prevent the formation of condensation on the glass surface by incorporating heat reflective coatings on the glass, gas inserted between the panes, non-metallic spacers to separate glass panes, and/or non-metallic frames.

This measure cannot be used in conjunction with anti-sweat heat (ASH) controls.

D.4.6.2. Baseline and Efficiency Standards

The baseline standard for this measure is a standard vertical reach-in refrigerated cooler or freezer with anti-sweat heaters on the glass surface of the doors.

The efficiency standard for this measure is a reach-in refrigerated cooler or freezer with special doors installed to eliminate the need for anti-sweat heaters. Doors must have either heat reflective treated glass, be gas-filled, or both.

D.4.6.3. Estimated Useful Life (EUL)

According to the California Database of Energy Efficiency Resources (DEER 2014), zero energy doors are assigned an EUL of 12 years.

D.4.6.4. Calculation of Deemed Savings

$$kW_{savings} = kW_{door} \times BF$$

$$kWh_{savings} = kW_{savings} \times 8760$$

Where:

kW_{door} = Connected load kW of a typical reach-in cooler or freezer door with a heater

BF = Bonus factor for reducing cooling load from eliminating heat generated by the door heater from entering the cooler or freezer

8760 = Annual operating hours

Table D-84: Assumptions for Savings Calculations

Variable	*Deemed Values*
kW_{door}[515]	Cooler: 0.075 Freezer: 0.200
BF[516]	Low-Temp Freezer: 1.3 Medium-Temp Cooler: 1.2 High-Temp Cooler: 1.1

D.4.6.5. Deemed Savings Values

Table D-85: Zero Energy Doors – Deemed Savings Values (per door)[517]

Measure	*kWh Savings*	*kW Savings*	*Measure*
Low-Temperature Freezer (< 25°F)	2,278	0.26	Low-Temperature Freezer (< 25°F)
Medium-Temperature Cooler (25° - 40°F)	2,102	0.24	Medium-Temperature Cooler (25° - 40°F)
High-Temperature Cooler (41° - 65°F)	723	0.08	High-Temperature Cooler (41° - 65°F)

D.4.6.6. Incremental Cost

The incremental cost is $290 per door.[518]

D.4.6.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. If this measure is added to Energy Smart, The TPE recommends a baseline study to capture the market share of ASH-controlled doors versus uncontrolled doors.

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515 Based on range of wattages from two manufacturers and metered data (cooler 50-130W, freezer 200-320W). Efficiency Vermont Commercial Master Technical Reference Manual No. 2005-37.

516 Bonus factor (1+0.65/COP) assumes 2.0 COP for low temp, 3.5 COP for medium temp, and 5.4 COP for high temp, based on the average of standard reciprocating and discuss compressor efficiencies with Saturated Suction Temperatures of -20ºF, 20ºF, and 45ºF, respectively, and a condensing temperature of 90ºF, and manufacturers assumption that 65% of heat generated by door enters the refrigerated case. Efficiency Vermont Commercial Master Technical Reference Manual No. 2005-37.

517 Temperature ranges based on Commercial Refrigeration Rebate Form, p, 3. Efficiency Vermont. https://www.efficiencyvermont.com/Media/Default/docs/rebates/forms/efficiency-vermont-commercial-refrigeration-rebate-form.pdf.

518 Vermont TRM

D.4.7. Evaporator Fan Controls

D.4.7.1. Measure Description

This measure applies to the installation of evaporator fan controls. As walk-in cooler and freezer evaporators often run continuously, this measure consists of a control system that turns the fan on only when the unit's thermostat is calling for the compressor to operate.

D.4.7.2. Baseline and Efficiency Standards

The baseline standard for this measure is an existing shaded pole evaporator fan motor with no temperature controls with 8,760 annual operating hours.

The efficiency standard for this measure is an energy management system (EMS) or other electronic controls to modulate evaporator fan operation based on temperature of the refrigerated space.

D.4.7.3. Estimated Useful Life (EUL)

According to the California Database of Energy Efficiency Resources (DEER 2014), evaporator fan controls are assigned an EUL of 16 years.[519]

D.4.7.4. Deemed Savings Values

Table D-86: Evaporator Fan Controls Deemed Savings Values

Measure	***kWh Savings***	***kW Savings***
Low-Temperature Freezer (< 25°F)	543	0.062
Medium-Temperature Cooler (25° - 40°F)	501	0.057
High-Temperature Cooler (41° - 65°F)	463	0.053

D.4.7.5. Calculation of Deemed Savings

The energy savings from the installation of evaporator fan controls are a result of savings due to the reduction in operation of the fan. The energy and demand savings are calculated using the following equations:

$$kW_{savings} = \left[\left(kW_{evap} \times n_{fans}\right) - kW_{circ}\right] \times \left(1 - DC_{comp}\right) \times DC_{evap} \times BF$$

$$kWh_{savings} = kW_{savings} \times 8760$$

Where:

[519] Database for Energy Efficient Resources (2014). http://www.deeresources.com/.

kW_{evap} = Nameplate connected load kW of each evaporator fan = 0.123 kW (default) [520]

kW_{circ} = Nameplate connected load kW of the circulating fan = 0.035 kW (default) [521]

n_{fans} = Number of evaporator fans

DC_{comp} = Duty cycle of the compressor = 50% (default) [522]

DC_{evap} = Duty cycle of the evaporator fan = Coolers: 100%; Freezers: 94% (default) [523]

BF = Bonus factor for reducing cooling load from replacing the evaporator fan with a lower wattage circulating fan when the compressor is not running = Low Temp.: 1.5, Medium Temp.: 1.3, High Temp.: 1.2 (default) [524]

8760 = Annual hours per year

D.4.7.6. Incremental Cost

The incremental cost is $291 per unit[525].

D.4.7.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure had low participation in Energy Smart programs. As a result, savings are calculated using weather-adjusted default values from other programs. If participation exceeds 500,000 kWh, the evaluation should include a metering study to support energy savings estimates.

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[520] Based on a weighted average of 80% shaded pole motors at 132 watts and 20% PSC motors at 88 watts.

[521] Wattage of fan used by Freeaire and Cooltrol.

[522] A 50% duty cycle is assumed based on examination of duty cycle assumptions from Richard Traverse (35%-65%), Control (35%-65%), Natural Cool (70%), Pacific Gas & Electric (58%). Also, manufacturers typically size equipment with a built-in 67% duty factor and contractors typically add another 25% safety factor, which results in a 50% overall duty factor.

[523] An evaporator fan in a cooler runs all the time, but a freezer only runs 8273 hours per year due to defrost cycles (4 20-min defrost cycles per day).

[524] Bonus factor (1+1/COP) assumes 2.0 COP for low temp, 3.5 COP for medium temp, and 5.4 COP for high temp, based on the average of standard reciprocating and discus compressor efficiencies with Saturated Suction Temperatures of -20°F, 20°F, and 45°F, respectively, and a condensing temperature of 90°F.

[525] CA DEER 2014

D.4.8. Beverage and Snack Machine Controls

D.4.8.1. Measure Description

This measure involves the installation of a beverage or snack machine control on an existing refrigerated beverage vending machine, refrigerated glass-front reach-in cooler, or non-refrigerated snack machine with a lighted display and no existing controls. Applicable control types include occupancy or schedule-based controls installed on the unit that will reduce energy consumption by powering down the refrigeration and lighting systems when the control does not detect human activity and by reducing the refrigeration process, while still maintaining product quality.

D.4.8.2. Baseline and Efficiency Standards

The baseline for this measure is an existing 120-volt single phase refrigerated or non-refrigerated beverage vending machine, refrigerated reach-in cooler, or non-refrigerated snack machine with a lighted display and no existing controls. Current federal regulations specify that refrigerated bottled or canned beverage vending machines manufactured on or after August 31, 2012 must meet increased energy conservation standards.[526,527] Therefore, any vending machine occupancy controls installed on refrigerated beverage vending machines must be installed on machines that were manufactured and purchased before August 31, 2012 to be eligible for this measure.

D.4.8.3. Estimated Useful Life (EUL)

The estimated useful life (EUL) for this measure for occupancy-based vending controls is five years.[528] The EUL for schedule-based controls is ten years.[529]

[526] U.S. DOE. Refrigerated Beverage Vending Machines: Standards and Test Procedures. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/24.

[527] Refrigerated bottled or canned beverage vending machines manufactured on or after August 31, 2012 must meet the energy conservation standards specified in the Code of Federal Regulations, 10 CFR 421.296. http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec431-292.pdf

[528] Database for Energy Efficiency Resources (DEER) 2014. Used value specified for Vending Machine Controllers.

[529] Energy & Resource Solutions (ERS), "Measure Life Study". Prepared for the Massachusetts Joint Utilities. November 17, 2005. Used median value specified for Novelty Cooler Shutoff.

D.4.8.4. Calculation of Deemed Savings

D.4.8.4.1. Energy Savings

The following energy savings estimates align conservatively with various other vending miser energy savings studies.[530,531,532] Additionally, in comparing to savings calculation methodologies for schedule-based controls from other TRMs, the energy savings factors defined in this measure produce energy savings that are more in line with expected savings percentages. This is likely due to the exclusion of a morning start-up penalty, used to represent the additional energy required to return to typical operating temperatures, from some TRMs.[533]

$$kWh_{Savings} = W_{CL} \times \frac{1\ kW}{1000\ W} \times AOH \times ESF$$

Where:

W_{CL} = Connected load of controlled beverage or snack machine; if unknown, use default values from Table D-87.

AOH = Annual Operating Hours = 8,760 hours for occupancy-based controls; for schedule-based controls, assume one less hour than the number of hours that the installation location is closed per day

ESF = Energy Savings Factor from Table D-88

Table D-87: Default Connected Load by Machine Type

Machine Type	***Connected Load (W)***
Refrigerated beverage vending machine	400
Refrigerated glass-front reach-in cooler	460
Non-refrigerated snack vending machine	85

[530] Deru, M., et. al. 2003, "*Analysis of NREL Cold-Drink Vending Machines for Energy Savings*". June. National Renewable Energy Laboratory (NREL). http://www.nrel.gov/docs/fy03osti/34008.pdf

[531] Foster-Miller, Inc., "Vending Machine Energy Efficiency Device Engineering Evaluation and Test Report". June 1, 2000. Bayview Technology Group, Inc. http://www.energymisers.com/downloads/FosterMillerReportVMEnergyNoCover.pdf

[532] Ritter, J & Hugghins, J. 2000 Joel Hugghins, "Vending Machine Energy Consumption and Vending Miser Evaluation". October 31. Texas A&M Energy Systems Laboratory. http://repository.tamu.edu/bitstream/handle/1969.1/2006/ESL-TR-00-11-01.pdf

[533] Select Energy Services, Inc., "Analysis of Cooler Control Energy Conservation Measures: Final Report. March 3, 2004. Submitted to NSTAR Electric.

Table D-88: Energy Savings Factor by Machine Type[534]

Machine Type	ESF
Refrigerated beverage vending machine	46%
Refrigerated glass-front reach-in cooler	30%
Non-refrigerated snack vending machine	46%

D.4.8.4.2. Demand Savings

Metered data from a Sacramento Municipal Utility District (SMUD) program evaluation found an average demand impact of 0.030 kW/unit using a peak definition of 2 PM to 6 PM.[535] This impact equates to a 7.5% demand reduction, using the USA Technologies, Inc. controlled load estimate of 400 W for refrigerated beverage vending machines. Assuming a comparable load reduction for other equipment types, this measure estimates an average demand impact of 0.035 kW/unit for refrigerated reach-in coolers and 0.006 kW/unit for non-refrigerated snack vending machines.

No demand savings are claimed for schedule-based beverage and snack machine controls because energy savings typically occur during off-peak hours.

$$kW_{Savings} = W_{CL} \times \frac{1\ kW}{1000\ W} \times DSF$$

Where:

W_{CL} = Connected load of controlled beverage or snack machine; if unknown, use default values from Table D-87.

DSF = Demand Savings Factor = 7.5% (occupancy controls); 0% (schedule controls)

D.4.8.5. Deemed Savings Values

Table D-89: Occupancy-based Controls – Energy and Demand Savings by Machine Type

Machine Type	Annual Energy Savings (kWh/unit)	Peak Demand Savings (kW/unit)
Refrigerated beverage vending machine	1,612	0.030
Refrigerated glass-front reach-in cooler	1,209	0.035
Non-refrigerated snack vending machine	343	0.006

534 Product data sheets from USA Technologies, Inc. http://www.energymisers.com.

535 Chappell, C., et. al. 2002 "Does It Keep The Drinks Cold and Reduce Peak Demand?: An Evaluation of a Vending Machine Control Program". Heschong Mahone Group, Sacramento Municipal Utility District (SMUD), RLW Analytics, Inc., and American Council for an Energy-Efficient Economy (ACEEE). http://aceee.org/proceedings-paper/ss02/panel10/paper05

Table D-90: Schedule-based Controls – Energy and Demand Savings by Machine Type

Machine Type	Annual Energy Savings (kWh/unit)	Peak Demand Savings (kW/unit)
Refrigerated beverage vending machine	Use energy savings algorithms with site-specific annual operating hours	0
Refrigerated glass-front reach-in cooler		0
Non-refrigerated snack vending machine		0

D.4.8.6. Incremental Cost

Full measure cost should be used. If not available, use $180 for refrigerated machines and $80 for non-refrigerated machines[536].

D.4.8.7. Future Studies

This measure has received significant metering in support of its California DEER savings estimate, and the TPE has concluded that metering for New Orleans units would not add value to the precision of these savings estimates. Savings should be updated to correspond to CA DEER.

[536] Illinois TRM, based on ComEd workpapers

D.4.9. Commercial Ice Makers

D.4.9.1. Measure Description

This measure involves ENERGY STAR® air-cooled commercial ice makers in retrofit and new construction applications. Eligible equipment types are batch type (also known as cube-type) and continuous type (also known as nugget or flakers). Batch-type ice makers harvest ice with alternating freezing and harvesting periods and can be used in a variety of applications but are generally used to generate ice for use in beverages. Both types of equipment qualify based on their configuration as ice-making heads (IMHs), remote condensing units (RCUs) and self-contained units (SCUs). Remote condensing units designed for connection to a remote condenser rack are also eligible.

D.4.9.2. Baseline and Efficiency Standards

The ENERGY STAR®[537] criteria for ice makers define efficiency requirements for both energy and potable water use. The baseline standard for batch ice makers are federal minimum levels that went into effect January 28, 2018. The following four tables show the standards and requirements for equipment manufactured on or after January 28, 2018.

Table D-91: Federal Minimum Standards for Air-Cooled Batch Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***
Ice Making Heads	< 300	10.0 – 0.01233H
	≥ 300 and < 800	7.05 – 0.0025H
	≥ 800 and < 1,500	5.55 – 0.00063H
	≥ 1,500	4.61
Remote Condensing Units (w/out remote compressor)	< 988	7.97 – 0.00342H
	≥ 988 and < 4,000	4.59
Remote Condensing Units (w/ remote compressor)	< 930	7.97 – 0.00342H
	≥ 934 and < 4,000	4.79
Self-Contained Units	< 110	14.79 – 0.0469H
	≥ 110 and < 200	12.42 – 0.02533H
	≥ 200 and < 4,000	7.35

[537] ENERGY STAR® Commercial Ice Makers Version 3.0, effective on January 28, 2018.

Table D-92: Federal Minimum Standards for Air-Cooled Continuous Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***
Ice Making Heads	<310	9.19– 0.00629H
	≥310 and <820	8.23-0.0032H
	≥4,000	5.61
Remote Condensing Units (w/out remote compressor)	<800	9.7– 0.0058H
	≥800 and <4,000	5.06
Remote Condensing Units (w/ remote compressor)	<800	9.9– 0.0058H
	≥800 and <4,000	5.26
Self-Contained Units	<200	14.22–0.03H
	≥200 and <700	9.47-0.00624H
	≥700 and <4,000	5.1

Table D-93: ENERGY STAR® Requirements for Air-Cooled Batch Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***	***Potable Water Use (gal/100 lbs. ice)***
Ice Making Heads	≤ 300	≤ 9.2– 0.01134H	≤ 20.0
	≥ 300 and ≤ 800	≤ 6.49-0.0023H	≤ 20.0
	≥ 800 and ≤ 1,500	≤ 5.11-0.00058H	≤ 20.0
	≥ 1,500 and ≤ 4,000	≤ 4.24	≤ 20.0
Remote Condensing Units (w/out remote compressor)	≤988	≤ 7.17– 0.00308H	≤ 20.0
	≥988 and ≤4,000	≤ 4.13	≤ 20.0
Remote Condensing Units (w/ remote compressor)	≤988	≤ 7.17– 0.00308H	≤ 20.0
	≥988 and ≤4,000	≤ 4.13	≤ 20.0
Self-Contained Units	≤110	≤ 12.57 – 0.0399H	≤ 25.0
	≥110 and ≤200	≤ 10.56-0.0215H	≤ 25.0
	≥200 and ≤4,000	≤ 6.25	≤ 25.0

Table D-94: ENERGY STAR® Requirements for Air-Cooled Continuous Ice Makers

Equipment Type	Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)	Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)	Potable Water Use (gal/100 lbs. ice)
Ice Making Heads	< 310	≤ 7.90– 0.005409H	≤ 15.0
	≥ 310 and < 820	≤ 7.08-0.002752H	≤ 15.0
	≥ 4,000	≤ 4.82	≤ 15.0
Remote Condensing Units (w/out remote compressor)	< 800	≤ 7.76– 0.00464H	≤ 15.0
	≥ 800 and < 4,000	≤ 4.05	≤ 15.0
Remote Condensing Units (w/ remote compressor)	< 800	≤ 7.76– 0.00464H	≤ 15.0
	≥ 800 and < 4,000	≤ 4.05	≤ 15.0
Self-Contained Units	< 200	≤ 12.37–0.0261H	≤ 15.0
	≥ 200 and < 700	≤ 8.24-0.005429H	≤ 15.0
	≥ 700 and < 4,000	≤ 4.44	≤ 15.0

D.4.9.3. Estimated Useful Life (EUL)

According to DEER 2011, the average commercial ice maker will have a measure life of 10 years.

D.4.9.1. Energy and Demand Savings

Energy savings and demand reductions for commercial ice makers are based on the energy consumption from the harvesting of ice, either in batches or continuously. The following subsections outline deemed calculations for energy savings and demand reductions, respectively.

D.4.9.1.1. Calculation of Deemed Savings

Annual electric savings are calculated by determining the energy consumed for baseline ice makers compared against the energy consumed by qualifying ENERGY STAR® product using the harvest rate of the more efficient unit.

The following two equations show how energy savings and demand reductions can be calculated, respectively:

$$\Delta kWh = \frac{\left(kWh_{base,per\ 100\ lb} - kWh_{ee,per\ 100\ lb}\right)}{100} \times DC \times H \times 365$$

$$\Delta kW = \left(\frac{\Delta kWh}{HRS}\right) \times CF$$

Where:

$kWh_{base,per\ 100\ lb}$ = Calculated on the harvest rate and type of ice machine from the Federal Minimum Energy Consumption Rate relationships in Table D-128

$kWh_{ee,per\ 100\ lb}$ = Qualifying energy efficient model consumption found in the AHRI directory of certified products by model information.

100 = conversion factor to convert $kWh_{base,per\ 100\ lb}$ and $kWh_{ee,per\ 100\ lb}$ into

maximum kWh consumption per pound of ice
DC = Duty Cycle of the ice maker representing the percentage of time the ice machine is making ice = 0.75
H = Harvest Rate (lbs. of ice made per day)
365 = days per year
HRS = Annual operating hours = 365 * 24 = 8,760 hours/year
CF = 1.0

For example, the annual energy savings and demand reductions for a batch type IMH commercial ice maker with an ice harvest rate *(H)* of 550 lbs. of ice per day and a consumption rate of kWh/100 lbs. ice of 4.45 are calculated as:

$$\Delta kWh = \frac{\left((7.05 - 0.0025 \times 550) - 4.45\right)}{100} \times 0.75 \times 550 \times 365 = 1{,}844\ kWh$$

$$\Delta kW = \left(\frac{1{,}844\ kWh}{8{,}760\ hr/yr}\right) \times 1.0 = 0.2105\ kW$$

D.4.9.2. Incremental Cost[538]

Ice Harvest Rate (H)	*Incremental Cost*
100-200 lb. ice maker	$296
201-300 lb. ice maker	$312
301-400 lb. ice maker	$559
401-500 lb. ice maker	$981
501-1000 lb. ice maker	$1,485
1001-1500 lb. ice maker	$1,821
<1500 lb. ice maker	$2,194

D.4.9.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units rebated in the program.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

[538] These values are from electronic work papers prepared in support of San Diego Gas & Electric's "Application for Approval of Electric and Gas Energy Efficiency Programs and Budgets for Years 2009-2011", SDGE, March 2, 2009. https://www.sdge.com/node/709

D.5. Food Service

D.5.1. Commercial Griddles

D.5.1.1. Measure Description

This measure applies to ENERGY STAR® or its equivalent natural gas and electric commercial griddles in retrofit and new construction applications. This appliance is designed for cooking food in oil or its own juices by direct contact with either a flat, smooth, hot surface or a hot channeled cooking surface where plate temperature is thermostatically controlled.

Energy-efficient commercial electric griddles reduce energy consumption primarily through application of advanced controls and improved temperature uniformity. Energy efficient commercial gas griddles reduce energy consumption primarily through advanced burner design and controls.

D.5.1.2. Baseline and Efficiency Standards

Key parameters for defining griddle efficiency are Heavy Load Cooking Energy Efficiency and Idle Energy Rate. There are currently no federal minimum standards for Commercial Griddles, however, the American Society of Testing and Materials (ASTM) publishes Test Methods[539] that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

ENERGY STAR® efficiency requirements apply to single and double-sided griddles. The ENERGY STAR® criteria should be reviewed on an annual basis to reflect the latest requirements.

Table D-95: ENERGY STAR® Criteria[540] for Electric and Gas Single- and Double-Sided Griddles

Performance Parameters	***Electric Griddles***
Heavy-Load Cooking Energy Efficiency	≥70%
Idle Energy Rate	≤320 watts per ft^2

[539] The industry standard for energy use and cooking performance of griddles are ASTM F1275-03: Standard Test Method for the Performance of Griddles and ASTM F1605-01: Standard Test Method for the Performance of Double-Sided Griddles

[540] ENERGY STAR® Commercial Griddles Program Requirements Version 1.1, effective May 2009 for gas griddles and effective January 1, 2011 for electric.

D.5.1.3. Estimated Useful Life (EUL)

According to DEER 2014, commercial griddles are assigned an estimated useful life (EUL) of 12 years.[541]

D.5.1.4. Calculation of Deemed Savings

Annual savings can be calculated by determining the energy consumed by a standard efficiency griddle as compared with an ENERGY STAR® rated griddle.

For electric savings,

$$\Delta \text{kWh} = \text{kWhbase} - \text{kWheff}$$

$$\text{kWh(base or eff)} = \text{kWhcooking} + \text{kWhidle} + \text{kWhpreheat}$$

$$\text{kWhcooking} = \left(\text{LBfood} \times \frac{\text{Efood}}{\text{CookEff}}\right) \times \text{Days}$$

$$\text{kWhidle} = \text{IdleEnergy} \times \left(\text{DailyHrs} - \frac{\text{LBfood}}{\text{Capacity}} - \frac{\text{PreheatTime}}{60}\right) \times \text{Days}$$

$$\text{kWhpreheat} = \text{PreheatEnergy} \times \text{Days}$$

Key parameters used to compute savings are defined in Table D-96.

[541] Database for Energy Efficient Resources, 2008, http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

Table D-96: Energy Consumption Related Parameters for Commercial Griddles[542]

Parameter	Description	Value	Source
Daily Hrs.	Daily Operating Hours	12 hours	FSTC
Preheat Time	Time to Preheat (Min)	15 Minutes	FSTC
E_{food}	ASTM defined Energy to Food	0.139 kWh/lb., 475 Btu/if	FSTC
Days	Number of Days of operation	365 Days	FSTC
CookEff	Cooking Energy Efficiency (%)	See Table D-97	FSTC
IdleEnergy	Idle energy rate (kW), (Btu/h)		FSTC, ENERGY STAR®
Capacity	Production capacity (lbs./hr)		FSTC
Preheat Energy	kWh/day, Btu/day		FSTC
LB_{Food}	Food cooked per day (lb/day)		FSTC

General assumptions used for deriving deemed electric and gas savings are values are taken from the Food Service Technology Center (FSTC) work papers.[543] These deemed values assume that the griddles are 3 x 2 feet in size. Parameters in the table are per linear foot, with an assumed depth of 2 feet.

[542] Assumptions based on PG&E Commercial Griddles Work Paper developed by FSTC, May 22, 2012.

[543] FSTC food service equipment work papers submitted to CPUC for Energy Efficiency 2013-2014 Portfolio; document titled EnergyEfficiency2013-2014-Portfolio_Test_PGE_20120702_242194.zip

https://www.pge.com/regulation/EnergyEfficiency2013-2014-Portfolio/Testimony/PGE/2012/EnergyEfficiency2013-2014-Portfolio_Test_PGE_20120702_242194.zip.

Table D-97: Baseline and Efficient Assumptions for Electric Griddles

Parameter	**Baseline Electric Griddles**	**Efficient Electric Griddles**
Preheat Energy (kWh/ft.)	1.33	0.67
Idle Energy Rate (kW/ft.)	0.8	0.64
Cooking Energy Efficiency (%)	65%	70%
Production Capacity (lbs./h/ft.)	11.7	16.33
Lbs. of food cooked/day/ft.	33.33	33.33

Peak Demand Savings can be derived by dividing the annual energy savings by the operating Equivalent hours and multiplying by the Coincidence Factor.

$$\Delta \mathrm{kW} = \left(\frac{\Delta \mathrm{kWh}}{\mathrm{HOURS}}\right) \times \mathrm{CF}$$

Where:

ΔkWh = Annual energy savings (kWh)

4380 = Operating Equivalent hours = 365 x 12 = 4380 hours

0.84[544] = Coincidence Factor (CF)

D.5.1.5. Deemed Savings Values

Deemed savings based on the assumptions above are tabulated below per griddle, per linear foot.

[544] Coincidence factors utilized in other jurisdictions for Commercial Griddles vary from 0.84 to 1.0. The KEMA report titled “Business Programs: Deemed Savings Parameter Development,” November 2009 conducted for Wisconsin Focus on Energy lists Coincidence Factors by building type and identifies food service at 0.84.

Table D-98: Deemed Savings for Electric and Gas Commercial Griddles per Linear Foot

Measure Description	Deemed Savings per Griddle per linear foot	
	kW	kWh
Griddle, Electric, ENERGY STAR®	0.15	758

D.5.1.6. Incremental Cost

The incremental cost is $60 per linear foot of width of the unit[545].

D.5.1.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values from FSTC. If this measure is added to Energy Smart programs, the evaluation should include an assessment of actual usage schedules to replace the default FSTC schedule values.

[545] Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

D.5.2. Convection Ovens

D.5.2.1. Measure Description

High efficiency ovens exhibit better baking uniformity and higher production capacities while also including high-quality components and controls.

D.5.2.2. Estimated Useful Life (EUL)

According to the California Database of Energy Efficiency Resources (DEER 2014), all commercial ovens are assigned an estimated useful life (EUL) of 12 years.[546]

D.5.2.3. Baseline and Efficiency Standards

Efficient convection ovens are defined by ENERGY STAR® or its equivalent and apply to electric full-size and half-size convection ovens and gas full-size convection ovens. Full size ovens accept a minimum of five pans measuring 18 x 26 x 1-inch. Half size ovens accept a minimum of five sheet pans measuring 18 x 13 x 1-inch. The ENERGY STAR® criteria should be reviewed on an annual basis to reflect the latest requirements.

There are currently no federal minimum standards for Commercial Convection Ovens, however, the American Society of Testing and Materials (ASTM) publishes Test Methods[547] that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

Table D-99: ENERGY STAR® Criteria for Electric Convection Ovens[548]

Performance Parameters	Half Size Electric Ovens	Full Size Electric Ovens
Heavy-Load Cooking Energy Efficiency	≥71%	≥71%
Idle Energy Rate	≤1.0 kW	≤1.6 kW

D.5.2.4. Calculation of Deemed Savings

Annual savings can be calculated by determining the energy consumed by a standard efficiency convection oven as compared with an ENERGY STAR® rated convection oven.

$$\Delta kWh = kWhbase - kWheff$$

[546] Database for Energy Efficient Resources, 2008, http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

[547] The industry standard for energy use and cooking performance of convection ovens is ASTM F-2861-10, Standard Test Method for Enhanced Performance of Combination Oven in Various Modes.

[548] ENERGY STAR® Commercial Ovens Version 1.1, effective May 2009; Version 2.0 is currently under development to be releas`qed by 2013. New efficiency levels will be identified and scope will add Combination Ovens.

$$\text{kWh(base or eff)} = \text{kWhcooking} + \text{kWhidle} + \text{kWhpreheat}$$

$$\text{kWhcooking} = \left(\text{LB} \times \frac{\text{Efood}}{\text{CookEff}}\right) \times \text{Days}$$

$$\text{kWhidle} = \text{IdleEnergy} \times \left(\text{DailyHrs} - \frac{\text{LB}}{\text{Capacity}} - \frac{\text{PreheatTime}}{60}\right) \times \text{Days}$$

$$\text{kWhpreheat} = \text{PreheatEnergy} \times \text{Days}$$

General assumptions in Table D-100 are from the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator – Convection Ovens which refers to the Food Service Technology Center (FSTC) work papers and research.[549]

Table D-100: Baseline and Efficient Assumptions for Electric Convection Ovens

Parameter	***Half Size Electric Ovens***		***Full Size Electric Ovens***	
	Baseline Model	***Efficient Model***	***Baseline Model***	***Efficient Model***
Preheat Energy (kWh/ft.)	1	0.9	1.5	1
Idle Energy Rate (kW/ft.)	1.5	1	2	1.6
Cooking Energy Efficiency (%)	65%	71%	65%	71%
Production Capacity (lbs./h/ft.)	45	50	70	80
Lbs. of food cooked/day/ft.	100	100	100	100
Efood (kWh/lb)	0.0732	0.0732	0.0732	0.0732

Peak Demand Savings can be derived by dividing the annual energy savings by the operating Equivalent hours and multiplying by the Coincidence Factor.

$$\Delta kW = \left(\frac{\Delta kWh}{HOURS}\right) \times CF$$

Where:

ΔkWh = Annual energy savings (kWh)

[549] FSTC food service equipment work papers submitted to CPUC for Energy Efficiency 2013-2014 Portfolio; document titled EnergyEfficiency2013-2014-Portfolio_Test_PGE_20120702_242194.zip

$HOURS$ = Operating Equivalent hours = 365 x 12 = 4,380 hours[550]

CF = Coincidence Factor = 0.84[551]

D.5.2.5. Deemed Savings Estimates for Convection Ovens

Deemed savings based on the assumptions above are tabulated below for electric convection ovens.

Table D-101: Deemed Savings Estimates for Electric Convection Ovens

Measure Description	***Deemed Savings per Oven***	
	kWh	***kW***
Half-Size Convection Oven, Electric, ENERGY STAR®	2,042	0.39
Full-Size Convection Oven, Electric, ENERGY STAR®	1,933	0.37

D.5.2.6. Incremental Cost

The incremental cost for this measure is $50.[552]

[550] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator – Convection Ovens assumes an operating time of 12 hours.

[551] KEMA report titled "Business Programs: Deemed Savings Parameter Development," November 2009 conducted for Wisconsin Focus on Energy lists Coincidence Factors by building type and identifies food service at 0.84.

[552] Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

D.5.3. Combination Ovens

Combination ("Combi") ovens are convection ovens with a steam cooking mode.

D.5.3.1. Baseline and Efficiency Standards

There are currently no federal minimum standards for Commercial Combination Ovens, however, the American Society of Testing and Materials (ASTM) publishes Test Methods611 that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

As of January 1, 2014, efficient combination ovens are defined by ENERGY STAR® and apply to both electric and gas ovens. Combination ovens combines the function of hot air convection (oven mode), saturated and superheated steam heating (steam mode), and combination convection/steam mode for moist heating, to perform steaming, baking, roasting, rethermalizing, and proofing of various food products.

Table D-102: High Efficiency Requirements for Electric Combination Ovens by Pan Capacity

Mode	Idle Rate	Cooking Efficiency (%)
Electric, where P is ≥ 5 and ≤ 20		
Steam Mode	≤ 0.133P + 0.64 kW	≥ 55%
Convection Mode	≤ 0.08P + 0.4989 kW	≥ 76%

D.5.3.2. Calculation of Deemed Savings

Annual savings can be calculated by determining the energy consumed by a standard efficiency combination oven as compared with a high efficiency combination oven.

For electric savings,

$$\Delta kWh = kWhtotal, base - kWhtotal, eff$$

$$kWh(total, base\ or\ total, eff) = kWhoven + kWhsteam + kWhpreheat$$

$$kWh(oven\ or\ steam) = kWhcooking + kWhidle$$

$$kWhcooking\ (oven\ or\ steam) = (LBoven\ or\ steam \times \frac{Efood}{\text{CookEff}}) \times Days$$

Where $LB_{ove}n$ = LB × (1-% Steam) and LB_{steam} = LB × % Steam

$$kWhidle(oven) = (1 - \%Steam) \times IdleEnergy \times (DailyHrs - LBovenCapacity - nP \times PreheatTime60) \times Days$$

$$kWhidle(steam) = (\%Steam) \times IdleEnergy \times (DailyHrs - LBsteamCapacity - np \times PreheatTime60) \times Days$$

$$kWhpreheat = nP \times PreheatEnergy \times Days$$

Key parameters used to compute savings are listed in Table D-103,Table D-104, and Table D-105.

Table D-103: Energy Consumption Parameters for Commercial Combination Ovens

Parameter	***Description***	***Value***	***Source/Approach***
Daily Hrs.	Daily Operating Hours	12 hours	ENERGY STAR® Commercial Kitchen Equipment Calculator
Preheat Time	Time to Preheat (Min)	15 min	FSTC Life Cycle & Energy Cost Calculator
nP	Number of Preheats per Day	1/day	FSTC Life Cycle & Energy Cost Calculator
$E_{food,oven}$	ASTM defined Energy to Food for Convection Ovens	0.0732 kWh/lb	ASTM
$E_{food,steam}$	ASTM defined Energy to Food for Steam Cookers	0.0308 kWh.lb,	ASTM
Days	Number of days of operation	365 days	ENERGY STAR® Commercial Kitchen Equipment Calculator
% Steam	Percent of time in Steam Mode	50%	ENERGY STAR® Commercial Kitchen Equipment Calculator
CookEff	Cooking energy efficiency (%)	See Table D-102	Baseline: Average from ENERGY STAR® and FSTC Calculators[553]
IdleEnergy	Idle energy rate (kW), (Btu/h)		

[553] Baseline cooking efficiencies and idle energy rates were averaged between the ENERGY STAR® Food Service Appliance Calculator and the FSTC food service life cycle cost calculator.

Capacity	Production capacity (lbs./hr)		Average from ENERGY STAR® Qualifying Products Listing
Preheat Energy	kWh/day, Btu/day		FSTC Life Cycle & Energy Cost Calculator ENERGY STAR® Products Listing
$LB_{oven,steam}$	Food cooked per day (lb/day) in steam mode or oven mode		ENERGY STAR® Commercial Kitchen Equipment Calculator

General assumptions used for deriving deemed electric and gas savings are defined in the following tables. These values were taken from the ENERGY STAR® Food Service Appliance Calculator as well as the Food Service Technology Center (FSTC) Life Cycle and Energy Cost Calculator.

D.5.3.3. Incremental Cost

The incremental cost is $800[554].

D.5.3.4. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values from FSTC. If this measure is added to Energy Smart programs, the evaluation should include an assessment of actual usage schedules to replace the default FSTC schedule values.

[554] ENERGY STAR Commercial Food Service Calculator

D.5.4. Commercial Fryers

D.5.4.1. Measure Description

This measure applies to ENERGY STAR® or its equivalent electric commercial open-deep fat fryers in retrofit and new construction applications. Commercial fryers consist of a reservoir of cooking oil that allows food to be fully submerged without touching the bottom of the vessel. Electric fryers use a heating element immersed in the cooking oil.

High efficiency standard and large vat fryers offer shorter cook times and higher production rates through the use of advanced burner and heat exchanger design. Standby losses are reduced in more efficient models through the use of fry pot insulation.

D.5.4.2. Baseline & Efficiency Standard

Key parameters for defining fryer efficiency are Heavy Load Cooking Energy Efficiency and Idle Energy Rate. ENERGY STAR® requirements apply to a standard fryer and a large vat fryer. A standard fryer measures 14 to 18 inches wide with a vat capacity from 25 to 60 pounds. A large vat fryer measures 18 inches to 24 inches wide with a vat capacity greater than 50 pounds. The ENERGY STAR® criteria should be reviewed on an annual basis to reflect the latest requirements.

There are currently no federal minimum standards for Commercial Fryers, however, ASTM publishes Test Methods[555] that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

Table D-104: ENERGY STAR® Criteria[556] and FSTC Baseline for Open Deep-Vat Electric Fryers

Performance Parameters	ENERGY STAR® Electric Fryer Criteria	
	Standard Fryers	Large Vat Fryers
Heavy-Load Cooking Energy Efficiency	≥ 80%	≥ 80%
Idle Energy Rate	≤ 1.0 kW	≤ 1.1 kW

555 The industry standards for energy use and cooking performance of fryers are ASTM Standard Test Method for the Performance of Open Deep Fat Fryers (F1361) and ASTM Standard Test Method for the Performance of Large Vat Fryers (FF2144).

556

D.5.4.3. Estimated Useful Life (EUL)

According to DEER 2014, commercial fryers are assigned an estimated useful life (EUL) of 12 years.[557]

D.5.4.4. Calculation of Deemed Savings

Annual savings can be calculated by determining the energy consumed by a standard efficiency fryer as compared with an ENERGY STAR® rated fryer.

$$\Delta kWh = kWhbase - kWheff$$

$$kWh(base\ or\ eff) = kWhcooking + kWhidle + kWhpreheat$$

$$kWhcooking = \left(LB \times \frac{Efood}{CookEff}\right) \times Days$$

$$kWhidle = IdleEnergy\ \times \left(DailyHrs - \frac{LB}{Capacity} - \frac{PreheatTime}{60}\right) \times Days$$

$$kWhpreheat = PreheatEnergy\ \times Days$$

Key parameters used to compute savings are defined in Table D-105.

[557] Database for Energy Efficient Resources, 2008, http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

Table D-105: Energy Consumption Related Parameters for Commercial Fryers[558]

Parameter	***Description***	***Value***	***Source***
Daily Hrs.	Daily Operating Hours	12 hours	FSTC
Preheat Time	Time to Preheat (Min)	15 Minutes	FSTC
E_{food}	ASTM defined Energy to Food	0.167 kWh/lb, 570 Btu/lb.	FSTC
Days	Number of Days of operation	365 Days	FSTC
CookEff	Cooking Energy Efficiency (%)	See Table D-106	FSTC
IdleEnergy	Idle energy rate (kW), (Btu/h)		FSTC, ENERGY STAR®
Capacity	Production capacity (lbs./hr)		FSTC
Preheat Energy	kWh/day, Btu/day		FSTC
LB	Food cooked per day (lb/day)		FSTC

General assumptions used for deriving deemed electric and gas savings are defined in the following tables. These values are taken from the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator as well as the Food Service Technology Center (FSTC) work papers and research.

558 Assumptions based on PG&E Commercial Fryers Work Paper developed by FSTC, June 13, 2012

Table D-106: Baseline and Efficient Assumptions for Electric Standard and Large Vat Fryers

Parameter	**Baseline Electric Fryers**		**Efficient Electric Fryers**	
	Standard	**Large Vat**	**Standard**	**Large Vat**
Preheat Energy (kWh/ft.)	2.3	2.5	1.7	2.1
Idle Energy Rate (kW/ft.)	1.05	1.35	1	1.1
Cooking Energy Efficiency (%)	75%	70%	80%	80%
Production Capacity (lbs./h/ft.)	65	100	70	110
Lbs. of food cooked/day/ft.	150	150	150	150

Peak Demand Savings can be derived by dividing the annual energy savings by the operating Equivalent hours and multiplying by the Coincidence Factor.

$$\Delta kW = \left(\frac{\Delta kWh}{HOURS}\right) \times CF$$

Where:

ΔkWh = Annual energy savings (kWh)

$HOURS$ = Operating equivalent hours = 365 x 12 = 4,380

CF = Coincidence factor = 0.84[559]

D.5.4.5. Deemed Savings Values

Deemed savings using the assumptions above are tabulated below. These values are per installed unit based on the type of fryer.

Table D-107: Deemed Savings per Fryer Vat

Measure Description	**Deemed Savings per Fryer Vat**

[559] Coincidence factors utilized in other jurisdictions for Commercial Fryers vary from 0.84 to 1.0. The KEMA report titled "Business Programs: Deemed Savings Parameter Development," November 2009 conducted for Wisconsin Focus on Energy lists Coincidence Factors by building type and identifies food service at 0.84.

	kWh	kW
Fryer, Electric, ENERGY STAR®	1,057	0.2
Fryer, Large Vat, Electric, ENERGY STAR®	2,659	0.51

D.5.4.6. Incremental Cost

The incremental cost is $1,200[560].

D.5.4.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values from FSTC. If this measure is added to Energy Smart programs, the evaluation should include an assessment of actual usage schedules to replace the default FSTC schedule values.

[560] cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

D.5.5. Commercial Steam Cookers

D.5.5.1. Measure Description

This measure applies to ENERGY STAR® or its equivalent electric steam cookers in retrofit and new construction applications. Commercial steam cookers, also known as “compartment steamers,” vary in configuration and size based on the number of pans. High efficiency steam cookers offer shorter cook times, higher production rates and reduced heat loss due to better insulation and more efficient steam delivery system.

D.5.5.2. Baseline & Efficiency Standard

Key parameters for defining steam cookers efficiency are Heavy Load Cooking Energy Efficiency and Idle Energy Rate. ENERGY STAR® requirements apply to steam cookers based on the pan capacity. These criteria should be reviewed on an annual basis to reflect the latest ENERGY STAR® requirements.

There are currently no federal minimum standards for Commercial Steam Cookers, however, ASTM publishes Test Methods[561] that allow uniform procedures to be applied to each commercial cooking appliance for a fair comparison of performance results.

Table D-108: ENERGY STAR® Criteria for Electric Steam Cookers[562]

Pan Capacity	***Cooking Efficiency***	***Idle Rate (watts)***
3-pan	50%	400
4-pan	50%	530
5-pan	50%	670
6-pan and larger	50%	800

Table D-109: ENERGY STAR® Criteria for Gas Steam Cookers[563]

Pan Capacity	***Cooking Efficiency***	***Idle Rate (Btu/h)***
5-pan	38%	10,400
6-pan and larger	38%	12,500

[561] The industry standard for steam cookers energy use and cooking performance is ASTM Standard F1484-99, Test Method for the Performance of Steam Cookers/

[562] ENERGY STAR® Commercial Steam Cookers Version 1.2, effective August 1, 2003.

[563] ENERGY STAR® provides criteria for 3-pan, 4-pan but availability of products in this range is limited or unavailable.

D.5.5.3. Estimated Useful Life (EUL)

According to DEER 2014, steam cookers are assigned an estimated useful life (EUL) of 12 years.

D.5.5.4. Calculation of Deemed Savings

Energy savings for steam cookers is derived by determining the total energy consumed by standard steam cooker as compared with an ENERGY STAR® rated steam cooker. Total energy for a steam cooker includes the energy used during cooking, the energy used when the equipment is idling, the energy spent when set in a constant steam mode and the energy required during pre-heat.

$$\Delta Energy = Energybase, total - Energyeff, total$$

$$Energy(base, total\ or\ eff, total) = Energycooking + Energyidle + Energysteam + Energypreheat$$

where,

$$Energycooking = LB\ food \times EfoodCook\ Eff \times Days$$

$$Energyidle = (1 - \%Steam) \times IdleEnergy \times (DailyHrs - \frac{LBfood}{Capacity} - \frac{PreheatTime}{60}) \times Days$$

$$Energysteam = (\%Steam) \times \frac{Capacity \times Efood}{Cook\ Eff} \times \left(DailyHrs - \frac{LBfood}{Capacity} - \frac{PreheatTime}{60}\right) \times Days$$

$$Energypreheat = PreheatEnergy \times Days$$

General assumptions used for deriving deemed electric savings are defined in the following tables. These values are taken from the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator as well as the Food Service Technology Center (FSTC) work papers and research.

Table D-110: Energy Consumption Related Parameters for Commercial Steam Cookers

Parameter	Description	Value	Source/Approach
Daily Hrs.	Daily Operating Hours	12 hours	FSTC
Preheat Time	Steam Cooker Preheat Time (Min)	15 min	FSTC
E_{food}	ASTM defined Energy to Food	0.0308 kWh/lb, 105 Btu/lb	FSTC
Days	Number of days of operation	365 days	FSTC
CookEff	Cooking energy efficiency (%)	See Table D-111	FSTC
IdleEnergy	Idle energy rate (kW), (Btu/h)		FSTC, ENERGY STAR®
%Steam	Constant Steam energy use		FSTC
Capacity	Production capacity (lb/hr)		ENERGY STAR®
Preheat Energy	kWh/day, Btu/day		ENERGY STAR®
LB_{food}	Food cooked per day (lb/day)		ENERGY STAR®

Table D-111: Deemed Savings Assumptions for Electric Steam Cookers

Parameter	***Baseline Model***	***Efficient Electric Model***
Cooking Efficiency (%)	26%	50%
Preheat Energy (Btu)	1.5	1.5
Constant Steam Mode Time (%)	0.9	0.1
Lbs. of food Cooked/Day	100	100
Production Capacity (lbs./hr/pan)	23.33	16.67
Idle Energy Rate (kW/pan)	0.33	0.13

Peak Demand Savings can be derived by dividing the annual energy savings by the operating Equivalent hours and multiplying by the Coincidence Factor.

$$\Delta kW = \left(\frac{\Delta kWh}{HOURS}\right) \times CF$$

Where:

ΔkWh = Annual energy savings (kWh)

4380 = Operating Equivalent hours = 365 x 12 = 4380 hours

0.84[564] = Coincidence Factor (CF)

D.5.5.5. Deemed Savings Values

Deemed savings are per installed unit based on the number of pans per steam cooker.

Table D-112: Deemed Savings for Steam Cookers

Measure Description	***Deemed Savings***	
	kW	***kWh***
Steam Cooker, Electric, 3-pan - ENERGY STAR®	5.4	28,214
Steam Cooker, Electric, 4-pan - ENERGY STAR®	7.3	38,081
Steam Cooker, Electric, 5-pan - ENERGY STAR®	9.2	47,948
Steam Cooker, Electric, 6-pan - ENERGY STAR®	11.1	57,815

[564] Coincidence factors utilized in other jurisdictions for Commercial Steam Cookers vary from 0.84 to 1.0. The KEMA report titled “Business Programs: Deemed Savings Parameter Development,” November 2009 conducted for Wisconsin Focus on Energy lists Coincidence Factors by building type and identifies food service at 0.84.

D.5.5.1. Incremental Cost

The incremental cost is $2,490[565].

D.5.5.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. As a result, savings are calculated using default values from FSTC. If this measure is added to Energy Smart programs, the evaluation should include an assessment of actual usage schedules to replace the default FSTC schedule values.

[565] 32Source for efficient electric steamer incremental cost is $2,490 per 2009 PG&E Workpaper - PGECOFST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComEd C & I TRM.

D.5.6. Low-Flow Pre-Rinse Spray Valves

D.5.6.1. Measure Description

This measure consists of installing low-flow pre-rinse spray valves which reduce hot water use and save energy associated with heating the water. The low-flow pre-rinse spray valves have the same cleaning effect as the existing standard spray valves even though they use less water.

Savings are shown assuming two possible delivery channels:

1. Direct install retrofit of functioning equipment
2. Downstream rebate measure, replacing failed equipment, new construction.

D.5.6.2. Baseline & Efficiency Standard

For direct install (DI) PRSVs, a baseline of 1.60 GPM may be used. This code pre-dates the 2019 code change specifying 1.28 GPM[566].

For downstream rebates or replace on burnout, the baseline is 1.28 GPM.

The maximum flow rate of program-qualifying low-flow pre-rinse spray valves is 1.07 GPM. To qualify for savings the facility must have electric domestic hot water equipment.

D.5.6.3. Estimated Useful Life (EUL)

The effective useful life (EUL) of a PRSV is 5 years.[567]

DI PRSVs may claim two years of remaining useful life (RUL) at the 1.60 baseline, while the last three years must use the 1.28 GPM baseline. This results in a weighted useful life of 3.19 years for direct install PRSVs, using the early replacement baseline.

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[566] FEMP Performance Requirements for Federal Purchases of Pre-Rinse Spray Valves, Based on ASTM F2324-13: Standard Test Method for Pre-Rinse Spray Valves.

[567] FEMP Purchasing Specification for Energy-Efficiency Products, Pre-Rinse Spray Valves: http://www1.eere.energy.gov/femp/pdfs/pseep_spray_valves.pdf

D.5.6.4. Deemed Savings Values

Table D-113: Deemed Savings – Direct Install

Facility Type	Days/Year	Minutes/Day	kWh	kW
Fast Food	365	45	980	0.134
Casual Dining	365	105	2,287	0.251
Institutional	365	210	4,574	0.376
Dormitory	274	210	3,434	0.501
K-12 School	200	105	1,253	0.313

Table D-114: Deemed Savings – Rebate/ROB/NC

Facility Type	Days/Year	Minutes/Day	kWh	kW
Fast Food	365	45	388	0.053
Casual Dining	365	105	906	0.099
Institutional	365	210	1,813	0.149
Dormitory	274	210	1,361	0.199
K-12 School	200	105	497	0.124

D.5.6.5. Calculation of Deemed Savings

Annual kWh electric and peak kW savings can be calculated using the following equations and

Table D-115 summarizes the needed variables:

$$\Delta kWh = \frac{\rho \times CP \times U \times (FB - FP) \times (TH - TSupply) \times \frac{1}{Et} \times \frac{Days}{Year}}{3412BTU/kWh}$$

$$\Delta kW = \frac{\rho \times CP \times U \times (FB - FP) \times (TH - TSupply) \times \frac{1}{Et} \times P}{3412BTU/kWh}$$

Table D-115: Variables for the Deemed Savings Algorithm

Parameter	Description	Value
F_B	Direct Install Average baseline flow rate of sprayer (GPM)	1.60
	Downstream Rebate Average baseline flow rate of sprayer (GPM)	1.28
F_P	Average post measure flow rate of sprayer (GPM)	1.07
Days/Year	Annual Operating Days for the applications: See Table D-116 for building type definitions:	
	1. Fast Food Restaurant	365[568]
	2. Casual Dining Restaurant	365
	3.Institutional	365
	4. Dormitory	274[569]
	5. K-12 School	200
T_{supply}	Average supply (cold) water temperature (°F)	74.8
T_H	Average mixed hot water (after spray valve) temperature (°F)	120[570]
U_B	Baseline water usage duration for the following applications:	
	1. Fast Food Restaurant (see Table D-117 - small service)	45 min/day/unit[571]

[568] Osman S &. Koomey, J. G. , . Lawrence Berkeley National Laboratory 1995. Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting. December.

[569]For dormitories with few occupants in the summer: 365 x (9/12) = 274.

[570] According to ASTM F2324 03 Cleanability Test the optimal operating conditions are at 120ºF.

[571] CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Valves.

	2. Casual Dining Restaurant (see Table D-117- medium service)	105 min/day/unit
	3. Institutional (see Table D-117- large service)	210 min/day/unit
	4. Dormitory (see Table D-117- large service)	210 min/day/unit
	5. K-12 School (see Table D-117- medium service)	105 min/day/unit[572]
ρ	Density of water 8.33 lbs./Gallon	8.33
C_P	Heat capacity of water, 1 BTU/lb·°F	1
E_t	Thermal efficiency of water heater	Default value 0.98 for electric and 0.80 for gas
P	Hourly peak demand as a fraction of daily water consumption for the following applications:	
	1. Fast food restaurant (Fast Food)	0.05[573]
	2. Casual Dining Restaurant (Sit Down Rest.)	0.04
	3. Institutional (Nursing Home)	0.03
	4. Dormitory (Sit Down Rest.)	0.04
	5. K-12 School (High School)	0.05

[572] School mealtime duration is assumed to be half of that of institutions, assuming that institutions (e.g. prisons, university dining halls, hospitals, nursing homes) serve three meals per day at 70 minutes each, and schools serve breakfast to half of the students and lunch to all, yielding 105 minutes per day.

[573] ASHRAE Handbook 2011. HVAC Applications. Chapter 50 –Service Water Heating. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) 2011. ASHRAE, Inc., Atlanta, GA.

Table D-116: Building Type Definitions

Building Type	***Operating Days per Year***	***Representative PRSV Usage Examples***
1. Fast food restaurant	365	Establishments engaged in providing food services where patrons order and pay before eating. These facilities typically use disposable serving ware. PRSV are used for rinsing cooking ware, utensils, trays, etc. Examples: Fast food restaurant, supermarket food preparation and food service area, drive-ins, grills, luncheonettes, sandwich, and snack shops.
2. Casual dining restaurant	365	Establishments primarily engaged in providing food services to customers who order and are served while seated (i.e. waiter/waitress service). These facilities typically use chinaware and use the PRSV to rinse dishes, cooking ware, utensils, trays, etc. Example: Full meal restaurant.
3. Institutional	365	Establishments located in institutional facilities (e.g. nursing homes, hospitals, prisons, military) where food is prepared in large volumes and patrons order food before eating, such as in dining halls and cafeterias. These facilities typically use disposable serving ware and serving trays. PRSVs are used for rinsing cooking ware, utensils, tray, etc. Examples: Nursing home, hospital, prison cafeteria, and military barrack mess hall.
4. Dormitory	274	Establishments located in higher education facilities where food is prepared in large volumes and patrons order food before eating, such as in dining halls and cafeterias. These facilities typically use disposable serving ware and serving trays. PRSVs are used for rinsing cooking ware, utensils, trays, etc. Example: University dining halls.
5. K-12 school	200	Establishments located in K-12 schools where food is prepared in large volumes and patrons order food before eating, such as in dining halls and cafeterias. These facilities typically use disposable serving ware and serving trays. PRSVs are used for rinsing cooking ware, utensils, trays, etc. Example: K-12 school cafeterias

Table D-117: Daily Operating Hours

Food Service Operation	Min (Min/Day)	Max (Min/Day)	Average (Min/Day)
Small Service (e.g., quick-service restaurants)	30	60	45
Medium Service (e.g., casual dining restaurants)	90	120	105
Large Service (e.g., institutional such as cafeterias in universities, prisons, and nursing homes)	180	240	210

The following are example calculations for a fast food restaurant in New Orleans using the previous equations.

$$Direct\ Install\ \Delta kWh = \frac{8.33\ BTU/Gal\ x\ 45\ minday\ x\ (1.60 - 1.07)GPM\ x\ (120 - 74.8\text{°F})x\ \left(\frac{1}{0.98}\right)\ x\ \frac{365\ days}{year}}{3412\ BTU/kWh}$$
$$= 980\ kWh$$

$$Direct\ Install\ \Delta kW = \frac{0.05\ x\ 8.33\ x\ 45\ minday\ x\ (1.60 - 1.07)GPM\ x\ (120 - 74.8\text{°F})\ x\ \left(\frac{1}{0.98}\right)}{3412\ BTU/kWh}$$
$$= 0.134\ kW$$

$$ROB\ \Delta kWh = \frac{8.33\ BTU/Gal\ x\ 45\ minday\ x\ (1.28 - 1.07)GPM\ x\ (120 - 74.8\text{°F})x\ \left(\frac{1}{0.98}\right)\ x\ \frac{365\ days}{year}}{3412\ BTU/kWh}$$
$$= 388\ kWh$$

$$Direct\ Install\ \Delta kW = \frac{0.05\ x\ 8.33\ x\ 45\ minday\ x\ (1.28 - 1.07)GPM\ x\ (120 - 74.8\text{°F})\ x\ \left(\frac{1}{0.98}\right)}{3412\ BTU/kWh}$$
$$= 0..053\ kW$$

$$Lfetime\ \Delta kWh = 980\ kWh * 2\ years\ RUL + 388 * 3\ years = 3{,}124\ kWh$$

D.5.6.6. Incremental Cost

For direct install, program-actual costs should be used when available. If unknown, use a default value of $92.90[574].

For downstream rebate / replace on burnout / new construction, use $46.12.[575]

D.5.6.7. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. If this measure is incorporated into Energy Smart, the TPE recommends studying the following parameters:

- DHW setpoint;
- Flow rate of installed PRSVs;
- Flow rate of baseline PRSVs (to be collected by the program implementer and sent to the TPE for testing).

[574] Average of costs recognized by Ameren Missouri ($85.8) and KCPL ($100).

[575] CA DEER Workpaper SWFS013-01, authored by Southwest Gas (2010)

D.5.7. Demand Control Ventilation (Kitchens)

D.5.7.1. Measure Description

Commercial Demand Control Kitchen Ventilation (DCKV) systems are a technology implemented in a variety of commercial kitchen types in order to reduce energy use associated with ventilation fan energy use as well as the HVAC energy use associated with conditioning the requisite make up air (MAU). The systems incorporate sensors and variable speed controls in order to operate the ventilation equipment only when it is necessary.

D.5.7.2. Baseline and Efficiency Standards

The baseline for this measure is a commercial kitchen exhaust fan controlled with a simple on/off switch that operates at one fixed speed and can optionally include an MAU to resupply a portion of the ventilation air. The efficient case is a ventilation fan controlled by a DCKV system which modifies the fan speed depending on the requirements within the kitchen and cooking appliances.

D.5.7.3. Deemed Savings Values

Table D-118: Deemed Savings per Rated Exhaust kW by Building Type, with or without Dedicated MAU

Building Type	Energy Savings ($kWh/kW_{exhaust}$)		Demand Savings ($kW/kW_{exhaust}$)		Heating Savings[576] ($kWh / kW_{exhaust}$)	Cooling Savings ($kWh / kW_{exhaust}$)
	MAU	No MAU	MAU	No MAU		
Supermarket	4,731	3,519	0.975	0.725	1,479	1,925
Restaurant[577]	5,492	4,085	0.975	0.725	1,717	2,235
Hotel	8,022	5,967	0.975	0.725	2,507	3,264
Campus	4,808	3,576	0.975	0.725	1,503	1,957
K-12 School, Inc Summer Sessions	3,205	2,384	0.975	0.725	1,002	1,304
K-12 School, No Summer Sessions	2,340	1,740	0.975	0.725	731	952

If exhaust fan is only rated in horsepower, use the conversion 1 hp = 0.746 kW

[576] Heating and cooling savings are assumed to be the same with or without an MAU. This is because any exhaust air will be replaced with outside air by the MAU or via increased infiltration proportional to exhaust airflow and thus will result in the same impact on heating and cooling equipment regardless of infiltration method. The savings calculation methodology was obtained from Work Paper SCE13CC008 (discussed below) and the AR TRM which also did not differentiate between MAU and non-MAU facilities.

[577] Source data (discussed below) included various restaurant types thus this value is applicable for all full service and fast-food kitchens.

D.5.7.4. Calculation of Deemed Savings

Deemed demand and annual savings are based on average fan kW reductions, HVAC savings, and hours of use by kitchen type as calculated using Southern California Edison work paper SCE13CC008[578], and the AR TRM 8.1. Average fan energy savings (kW/kW) were calculated based on whether the kitchen had a dedicated MAU or not. The hours of use and annual days of operation were calculated from 72 surveyed sites with DCKV systems as well as 11 metered sites. For the School hours of use and days of operation, the AR TRM 8.1 was referenced.

Table D-119: Annual Hours of Operation by Building Type

Building Type	Annual Operating Hours
Supermarket	4,864
Restaurant	5,652
Hotel	8,226
College / University	4,939
Institutional	6,789
K-12 School, Inc Summer Sessions	3,288
K-12 School, No Summer Sessions	2,400

Using the savings data from SCE13CC008 for 16 climate zones in CA, along with Heating Degree Day (HDD) and Cooling Degree Day (CDD) data for these climate zones[579], a linear regression was performed to calibrate heating and cooling load with New Orleans weather. The subsequent regression models had R-square values of 0.969 and 0.890 for heating and cooling energy load respectively thus indicating a high degree of confidence in calculated loads for New Orleans. The regressed values were then normalized to the average rated exhaust horsepower of 14.3 HP based on the 72 sites' data in SCE13CC008, and divided by the 17 hours per day and 365 days per year as input into the Outdoor Air Calculator by the work paper author. Thus, using these HVAC load values, the operation profiles calculated in the table above, and the average 25% reduction in exhaust fan airflow as calculated in SCE13CC008, the deemed HVAC savings values were calculated for each building type.

[578] "Commercial Kitchen Exhaust Hoods Demand Controlled Ventilation." Work Paper SCE13CC008. Southern California Edison Company. 11 June, 2014 Accessed from: http://www.deeresources.net/workpapers

[579] "The Pacific Energy Center's Guide to: California Climate Zones and Bioclimatic Design." October 2006. Retrieved from: https://www.pge.com/includes/docs/pdfs/about/edusafety/training/pec/toolbox/arch/climate/california_climate_zones_01-16.pdf

Table D-120: Regressed Load Savings Calibrated for NOLA

Fan Type	***Demand Savings ($kW/kW_{exhaust}$)***	***Heating Savings (kWh/kW/hr/day)***	***Cooling Savings (kWh/kW/hr/day)***
MAU	0.975	0.305	0.397
No MAU	0.725	0.305	0.397

$$Savings_{kWh} = Demand\ Savings \times CAP \times AOH$$

$$Savings_{kW} = Demand\ Savings \times CAP$$

Where:

Demand Savings = Fan demand reduction per rated kW of exhaust fan, $kW/kW_{exhaust}$. See Table D-120.

CAP = Rated capacity of exhaust fan, kW

AOH = Annual Operating Hour of operation, day(s). See Table D-119.

$$kWh\ Savings_{Heating} = \frac{Heating\ Savings \times kW_{exhaust} \times AOH}{Eff_{heat}}$$

$$kWh\ Savings_{Cooling} = \frac{Cooling\ Savings \times kW_{exhaust} \times AOH}{Eff_{cool}}$$

Where:

Heat Reduction = Heating energy savings per rated exhaust kW, kWh/kW/hr/day. See Table D-120.

Cool Reduction = Cooling energy savings per rated exhaust kW, kWh/kW/hr/day. See Table D-120.

$kW_{exhaust}$ = Rated kW of the installed exhaust fan, kW

AOH = Annual Operating Hour of operation. See Table D-119.

Eff_{heat} = Efficiency of heating system (%)

Eff_{cool} = Efficiency of cooling system (%)

D.5.7.5. Estimated Useful Life (EUL)

According to DEER 2014 the EUL of this measure is 15 years[580].

D.5.7.6. Incremental Cost

The incremental cost is $2,383 per exhaust fan rated HP[581].

[580] DEER 2014 for Variable Speed Drive controlled by CO2 sensor for HVAC-VSD-DCV

[581] "Commercial Kitchen Exhaust Hoods Demand Controlled Ventilation." Work Paper SCE13CC008. Southern California Edison Company. 11 June, 2014

D.5.8. ENERGY STAR® Hot Food Holding Cabinets

D.5.8.1. Measure Description

Hot Food Holding Cabinets (HFHC) keep cooked foods hot, fresh, and out of temperature danger zones until customers are ready to order. Cabinets that meet the ENERGY STAR requirements often incorporate better insulation which reduces heat loss, offers better temperature uniformity within the cabinet from top to bottom and keeps the external cabinet cooler. In addition, many certified cabinets may include additional energy saving devices such as magnetic door gaskets, auto-door closures, or Dutch doors. Savings occur from reduced idle energy consumption. ENERGY STAR models are, on average, 70 percent more energy efficient than standard models.

D.5.8.1.1. Qualification Criteria

To qualify for this measure the installed equipment must be an ENERGY STAR certified HFHC. Qualification is based upon idle energy consumption per given interior cabinet volumes, measured in cubic feet. Measuring cabinet interior volume: Commercial hot food holding cabinet interior volume shall be calculated using straight-line segments following the gross interior dimensions of the appliance and using Equation 3 below. Interior volume shall not account for racks, air plenums or other interior parts.

Equation 3: Interior Volume

$$Interior\ Volume = Interior\ Height \times Interior\ Width\ \times Interior\ Depth$$

Table D-121: Maximum Idle Energy Requirements for ENERGY STAR Qualification

Product Interior Volume (Cubic Feet)	***Product Idle Energy Consumption Rate (Watts)***
0 < Volume < 13	≤ 21.5 x Volume
13 ≤ Volume <28	≤ (2.0 x Volume) + 254.0
28 ≤ Volume	≤ (3.8 x Volume) + 203.5

D.5.8.2. Baseline

The baseline equipment is an electric HFHC that's not ENERGY STAR certified and at end of its life. Baseline energy use is 40 watts per cubic foot[582].

582 https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator_0.xlsx

D.5.8.3. Estimated Useful Life (EUL)

According to ENERGY STAR[583], the estimated useful life for HFHC is 12 years.

D.5.8.4. Deemed Savings Values

Custom calculation below, otherwise use deemed values depending on HFHC size:

Table D-122: HFHC Deemed Savings

Cabinet Size	Savings (kWh)	Savings (kW)
Full Size (20 cubic feet) HFHC	2,772	0.204
¾ Size (12 cubic feet) HFHC	1,216	0.090
½ Size (8 cubic feet) HFHC	811	0.060

D.5.8.5. Calculation of Deemed Savings

D.5.8.5.1. Energy Savings

$$kWh_{savings} = Baseline_{kWh} - Efficient_{kWh}$$

Where:

$$Baseline_{kWh} = \frac{Power_{Baseline} \times Hours_{Day} \times Days}{1000}$$

And

$$Efficient_{kWh} = \frac{Power_{ENERGY\ STAR} \times Hours_{Day} \times Days}{1000}$$

Where:

$Hours_{Day}$= Custom. If Unknown, use 15[2].

$Days$ = Custom. If Unknown, use 365.25[2].

$Power_{Baseline}$ = Baseline power consumption = Cubic feet × 40W/ft[3]

$Power_{ENERGY\ STAR}$ = Custom idle power consumption using ENERGY STAR idle power consumption (see Table D-121).

[583] ENERGY STAR Commercial Kitchen Equipment Calculator: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator_0.xlsx

D.5.8.5.2. Demand Savings

Demand savings are calculated using the following equation:

$$kW_{savings} = \frac{kWh_{savings}}{AOH} \times CF$$

CF = Coincidence factor[584]

Table D-123: HFHC Peak Coincidence Factors

Location	CF
Fast Food Limited Menu	0.30
Fast Food Expanded Menu	0.40
Pizza	0.50
Full Service Limited Menu	0.50
Full Service Expanded	0.40
Cafeteria	0.40

For example, if an 18ft^3 HFHC is installed in a cafeteria the measure would save:

kWh = ((18*40)-((18*2.0)+254)) × 15 × 365.25/1000

= (720 – 290) × 15 × 365.25/1000

=2,356 kWh

And

kW = (2,356kWh/(15*365.25)) × 0.40

=0.43 × 0.40

=0 .17 kW

D.5.8.6. Incremental Cost

The incremental cost is $902[585].

[584] Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

[585] Based on the difference between a similar ENERGY STAR and non-qualifying model, EPA research using AutoQuotes, July 2016

D.5.9. ENERGY STAR® Commercial Dishwashers

D.5.9.1. Measure Description

This measure defines energy savings and peak reductions from ENERGY STAR® commercial dishwashers in retrofit and new construction applications. Commercial dishwashers, also known as "warewashers," fall into two categories of machine type: stationary rack machines (under counter, single tank/door type, glasswashing, and pot, pan and utensil) and conveyor machines (rack and rackless/flight type, single and multiple tank). Key parameters used to characterize the efficient performance of commercial dishwashers are Idle Energy Rate and Water Consumption Rate. Energy savings from commercial dishwashers is primarily attributed to reducing the amount of water used which reduces the energy consumed to heat that water. This is accomplished via combinations of the following:

- Improved nozzle and rinse arm design
- Auxiliary pre-rinse section
- Heat recovery technology
- Sophisticated controls and sensors
- Effective curtain designs to minimize airflow
- Auto-mode capabilities, including low power mode during long periods of idle

Eligible Products: High temp (hot water sanitizing), low temp (chemical sanitizing) machines, and dual sanitizing machines.

Ineligible Products: Steam, gas, and other non-electric models; dishwashers intended for use in residential or laboratory applications.

D.5.9.2. Baseline & Efficiency Standard

Descriptions of commercial dishwasher configurations, as defined by ENERGY STAR, are as follows:

Stationary Rack Machines – A dishwashing machine in which a rack of dishes remains stationary within the machine while subjected to sequential wash and rinse sprays. This definition also applies to machines in which the rack revolves on an axis during the wash and rinse cycles.

- **Under Counter** – A stationary rack machine with an overall height of 38 inches or less, designed to be installed under food preparation workspaces. Under counter dishwashers can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
- **Stationary Single Tank Door** – A stationary rack machine designed to accept a standard 20" x 20" dish rack, which requires the raising of a door to place the rack into the wash/rinse chamber. Closing of the door typically initiates the wash cycle.

Single tank door type models can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.

- **Pot, Pan, and Utensil** – A stationary rack, door type machine designed to clean and sanitize pots, pans, and kitchen utensils.

Conveyor Machines – A dishwashing machine that employs a conveyor or similar mechanism to carry dishes through a series of wash and rinse sprays within the machine.

- **Single Tank Conveyor** – A conveyor machine that includes a tank for wash water followed by a sanitizing rinse (pumped or fresh water). This type of machine does not have a pumped rinse tank. This type of machine may include a pre-washing section ahead of the washing section and an auxiliary rinse section, for purposes of reusing the sanitizing rinse water, between the power rinse and sanitizing rinse sections. Single tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
- **Multiple Tank Conveyor** – A conveyor type machine that includes one or more tanks for wash water and one or more tanks for pumped rinse water, followed by a sanitizing rinse. This type of machine may include a pre-washing section before the washing section and an auxiliary rinse section, for purposes of reusing the sanitizing rinse water, between the power rinse and sanitizing rinse sections. Multiple tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.

Each of these machines are further classified by their rinse water washing strategies; high temperature, sanitized by heat with boost heating (~180º) and low temperature, sanitized by chemicals (~120º-140º). While less common, dual-method sanitization machines are also available.

There are currently no federal minimum standards for Commercial Dishwashers, however, the ASTM and the National Sanitation Foundation (NSF) publishes Test Methods[586] that allow uniform procedures to be applied to each commercial dishwasher for a fair comparison of performance results. To meet the strict efficiency requirements developed by the U.S. Environmental Protection Agency's ENERGY STAR program, manufacturers use high quality components and employ innovative designs. All ENERGY STAR certified machines are certified to NSF 3 sanitation standards.

[586] The industry standards for energy use is ASTM Standard F1920, Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines, ASTM Standard F1696, Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, Door-Type Commercial Dishwashing Machines and NSF/ANSI 3-2007 Standard, Commercial Warewashing Equipment.

Table D-124: ENERGY STAR[587] Requirements for Commercial Dishwashers[588]

Machine Type	High Temp Efficiency Requirements (~180°F)		Low Temp Efficiency Requirements (~120°F – 140°F)	
	Tank Heater Idle Energy Rate (kW)	Water Consumption	Tank Heater Idle Energy Rate (kW)	Water Consumption
Under Counter	≤ 0.50	≤ 0.86 GPR	≤ 0.50	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.70	≤ 0.89 GPR	≤ 0.60	≤ 1.18 GPR
Pot, Pan, and Utensil	≤ 1.20	≤ 0.58 GPSF	≤ 1.00	≤ 0.58 GPSF
Single Tank Conveyor	≤ 1.50	≤ 0.70 GPR	≤ 1.50	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 2.25	≤ 0.54 GPR	≤ 2.00	≤ 0.54 GPR

GPR = Gallons per Rack

GPSF = Gallons per Square Foot of Rack

GPH = Gallons per Hour

D.5.9.3. Estimated Useful Life[589] (EUL)

The estimated useful life (EUL) of commercial dishwashers vary based on the machine type. Under Counters have an EUL of 10 years, Door-Types have an EUL of 15 years and Conveyor Types have an EUL of 20 years.

D.5.9.4. Calculation of Deemed Savings[590]

Annual savings were calculated by determining the energy consumed for baseline commercial dishwashers compared against ENERGY STAR performance requirements. The annual energy consumption for commercial dishwashers was determined by the summation of the annual energy used for water heating, the booster heater and when the machine is in idle mode.

$$E_{total} = E_{DHW} + E_{boost} + E_{idle}$$

These are defined as follows for both gas and electric calculations:

[587] ENERGY STAR® Commercial Dishwashers Version 2.0 effective as of February 1, 2013. http://www.energystar.gov/index.cfm?c=comm_dishwashers.pr_crit_comm_dishwashers.

[588] ENERGY STAR® Commercial Dishwashers Version 2.0 includes 3 new dishwasher types: 1) Pot, Pan, and Utensil, 2) Single Tank Flight Type, and 3) Multiple Tank Flight Type. These new dishwasher types will be incorporated into the measure once they are incorporated into the ENERGY STAR® Commercial Dishwasher Savings Calculator.

[589] EUL values from CEE Program Design Guidance-Commercial Dishwashers, updated 5/11/2009.

[590] Assumptions from the ENERGY STAR® Commercial Dishwashers Savings Calculator (May 2013 update).

$$E_{DHW} = \frac{(RPD \times GPR \times Days \times d \times c_p \times \Delta T_{DHW})}{EF_{DHW} \times Conversion\ Factor}$$

$$E_{BOOST} = \frac{(RPD\ x\ GPR\ x\ Days\ x\ d\ x\ c_p\ x\ \Delta T_{BOOST})}{EF_{BOOST}\ x\ Conversion\ Factor}$$

(*only* applicable in High Temperature Machines)

$$E_{idle} = kW_{\text{idle}} \times \left(HRS - \frac{(RPD \times MPR)}{60}\right) \times \text{Days}$$

Where:

RPD = Average number of racks washed per day, varies by machine

GPR = Average gallons per rack used by dishwasher, varies by machine

Days = Operating Day per Year = 365 days/yr.

d = Density of water, constant value 8.34 lb/gal

c_p = Specific heat of water, 1 Btu/lb-ºF

ΔT_{DHW} = Temperature rise at primary water heater, 70ºF (default)

ΔT_{BOOST} = Temperature rise at booster heater, 40ºF (default)

EF_{DHW} = Efficiency of building water heater, 98% for electric (default), 80% for gas

EF_{BOOST} = Efficiency of booster water heater, 98% for electric (default), 80% for gas

$Conversion\ Factor$ = 100,000 Btu/therm or 3,413 Btu/kWh.

kW_{idle} = Energy consumed while idle, varies by machine

HRS = Hours per day dishwasher operates, 18 hours (default)

MPR = Time to wash one rack of dishes, minutes per rack, varies by machines

60 = Minutes per hour

To determine electric savings for the different types of commercial dishwashers, Table D-125 and

Table D-126 list the assumptions made for the machine dependent parameters; Idle Power, Racks per Day, Minutes per Rack and Gallons per Rack. Table D-125 lists the parameters for machines that employ Low Temperature cleaning and

Table D-126 lists parameters for machines that employ High Temperature cleaning.

Table D-125: Default Assumptions for Low Temperature, Electric and Gas Water Heaters

Performance	Under Counter		Single Tank Door		Single Tank Conveyor		Multi Tank Conveyor	
	Base	Change	Base	Change	Base	Change	Base	Change
Idle Power	0.5	0.5	0.6	0.6	1.6	1.5	2.0	2.0
Racks/Day	75	75	280	280	400	400	600	600
Min/Rack	2.0	2.0	1.5	1.5	0.3	0.3	0.3	0.3
Gal/Rack	1.73	1.19	2.1	1.18	1.31	0.79	1.04	0.54

Table D-126: Default Assumptions for High Temperature, Electric and Gas Water Heaters[4]

Performance	Under Counter		Single Tank Door		Single Tank Conveyor		Multi Tank Conveyor		Pot, Pan, and Utensil	
	Base	Change	Base	Change	Base	Change	Base	Change	Base	Change
Idle Power	0.76	0.5	0.87	0.7	1.93	1.5	2.59	2.25	1.2	1.2
Racks/Day	75	75	280	280	400	400	600	600	280	280
Min/Rack	2.0	2.0	1.0	1.0	0.3	0.3	0.2	0.2	3.0	3.0
Gal/Rack	1.09	0.86	1.29	0.89	0.87	0.70	0.97	0.54	0.70	0.58

Peak Demand Savings can be derived by dividing the annual energy savings by the operating hours and multiplying by the Coincidence Factor.

$$\Delta kW = \left(\frac{\Delta kWh}{HRS}\right) \times CF$$

Where:

ΔkWh = Annual energy savings (kWh)

HRS = Operating hours = 365 x 18 = 6,570 hours (default)

CF = Coincidence Factor = 0.84 (default)[591]

D.5.9.5. Deemed Savings Values

If specific equipment data is not available for use with the measure savings calculations described above, deemed electric and gas savings from ENERGY STAR commercial

[591] The KEMA report titled "Business Programs: Deemed Savings Parameter Development," November 2009 conducted for Wisconsin Focus on Energy lists Coincidence Factors by building type and identifies food service at 0.84.

dishwashers can be seen in Table D-127. Equipment savings are defined based on the following information:

- Dishwasher Type (Under Counter, Stationary Single Tank Door, Pots, Pans, and Utensils, Single Tank Conveyor, or Multiple Tank Conveyor)
- Water Temperature (Low Temperature or High Temperature)
- Building Water Heater Fuel (Electric or Gas)
- Booster Water Heater Fuel (Electric or Gas) *Only applicable in High Temperature Units*
- Default Assumptions from ENERGY STAR Commercial Dishwasher Savings Calculator.

Table D-127: Deemed Savings for Commercial Dishwashers

Water Temperature	***Water Heater Fuel/Booster Heater Fuel***	***Measure Description***	***kWh***	***kW***	***Therms***
High Temperature	Electric / Electric	Under Counter	3,171	0.4	--
		Stationary Single Tank Door	11,863	1.5	--
		Pots, Pans, and Utensils	3,311	0.4	--
		Single Tank Conveyor	9,212	1.2	--
		Multiple Tank Conveyor	27,408	3.5	--
	Gas / Electric	Under Counter	2,089	0.3	45.2
		Stationary Single Tank Door	4,840	0.6	294
		Pots, Pans, and Utensils	1,204	0.2	88
		Single Tank Conveyor	4,948	0.6	178
		Multiple Tank Conveyor	11,230	1.4	676
	Gas / Gas	Under Counter	1,471	0.2	71
		Stationary Single Tank Door	827	0.1	461
		Pots, Pans, and Utensils	--	--	138
		Single Tank Conveyor	2,511	0.3	280
		Multiple Tank Conveyor	1,986	0.3	1,063
Low Temperature	Electric / No Booster	Under Counter	2,540	0.3	--
		Stationary Single Tank Door	16,153	2.1	--
		Single Tank Conveyor	13,626	1.7	--
		Multiple Tank Conveyor	18,811	2.4	--
	Gas/ No Booster	Under Counter	--	--	106
		Stationary Single Tank Door	--	--	675
		Single Tank Conveyor	584	0.1	545
		Multiple Tank Conveyor	--	--	787

D.5.9.6. Incremental Cost

The incremental capital cost for this measure is provided below:[592]

Dishwasher Type		***Incremental Cost***
Low Temp	Under Counter	$50
	Stationary Single Tank Door	$0
	Single Tank Conveyor	$0
	Multi Tank Conveyor	$970
High Temp	Under Counter	$120
	Stationary Single Tank Door	$770
	Single Tank Conveyor	$2,050
	Multi Tank Conveyor	$970
	Pot, Pan, and Utensil	$1,710

D.5.9.7. Future Studies

This measure uses ENERGY STAR default inputs. Deemed savings should be updated to align with any applicable code updates.

[592] Measure cost from ENERGY STAR Commercial Kitchen Equipment Savings Calculator which cites reference as "EPA research on available models using AutoQuotes, 2012"

D.5.10. ENERGY STAR® Commercial Ice Makers

D.5.10.1. Measure Description

This measure involves ENERGY STAR® air-cooled commercial ice makers in retrofit and new construction applications. Eligible equipment types are batch type (also known as cube-type) and continuous type (also known as nugget or flakers). Batch-type ice makers harvest ice with alternating freezing and harvesting periods and can be used in a variety of applications but are generally used to generate ice for use in beverages. Both types of equipment qualify based on their configuration as ice-making heads (IMHs), remote condensing units (RCUs) and self-contained units (SCUs). Remote condensing units designed for connection to a remote condenser rack are also eligible.

D.5.10.2. Baseline and Efficiency Standards

The ENERGY STAR®[593] criteria for ice makers define efficiency requirements for both energy and potable water use. The baseline standard for batch ice makers are federal minimum levels that went into effect January 28, 2018. The following four tables show the standards and requirements for equipment manufactured on or after January 28, 2018.

Table D-128: Federal Minimum Standards for Air-Cooled Batch Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***
Ice Making Heads	< 300	10.0 – 0.01233H
	≥ 300 and < 800	7.05 – 0.0025H
	≥ 800 and < 1,500	5.55 – 0.00063H
	≥ 1,500	4.61
Remote Condensing Units (w/out remote compressor)	< 988	7.97 – 0.00342H
	≥ 988 and < 4,000	4.59
Remote Condensing Units (w/ remote compressor)	< 930	7.97 – 0.00342H
	≥ 934 and < 4,000	4.79
Self-Contained Units	< 110	14.79 – 0.0469H
	≥ 110 and < 200	12.42 – 0.02533H
	≥ 200 and < 4,000	7.35

593 ENERGY STAR® Commercial Ice Makers Version 3.0, effective on January 28, 2018.

Table D-129: Federal Minimum Standards for Air-Cooled Continuous Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***
Ice Making Heads	<310	9.19– 0.00629H
	≥310 and <820	8.23-0.0032H
	≥4,000	5.61
Remote Condensing Units (w/out remote compressor)	<800	9.7– 0.0058H
	≥800 and <4,000	5.06
Remote Condensing Units (w/ remote compressor)	<800	9.9– 0.0058H
	≥800 and <4,000	5.26
Self-Contained Units	<200	14.22–0.03H
	≥200 and <700	9.47-0.00624H
	≥700 and <4,000	5.1

Table D-130: ENERGY STAR® Requirements for Air-Cooled Batch Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***	***Potable Water Use (gal/100 lbs. ice)***
Ice Making Heads	≤ 300	≤ 9.2– 0.01134H	≤ 20.0
	≥ 300 and ≤ 800	≤ 6.49-0.0023H	≤ 20.0
	≥ 800 and ≤ 1,500	≤ 5.11-0.00058H	≤ 20.0
	≥ 1,500 and ≤ 4,000	≤ 4.24	≤ 20.0
Remote Condensing Units (w/out remote compressor)	≤988	≤ 7.17– 0.00308H	≤ 20.0
	≥988 and ≤4,000	≤ 4.13	≤ 20.0
Remote Condensing Units (w/ remote compressor)	≤988	≤ 7.17– 0.00308H	≤ 20.0
	≥988 and ≤4,000	≤ 4.13	≤ 20.0
Self-Contained Units	≤110	≤ 12.57 – 0.0399H	≤ 25.0
	≥110 and ≤200	≤ 10.56-0.0215H	≤ 25.0
	≥200 and ≤4,000	≤ 6.25	≤ 25.0

Table D-131: ENERGY STAR® Requirements for Air-Cooled Continuous Ice Makers

Equipment Type	***Ice Harvest Rate (H) (lbs. of ice / 24 hrs.)***	***Batch Ice Makers Consumption Rate (kWh/100 lbs. ice)***	***Potable Water Use (gal/100 lbs. ice)***
Ice Making Heads	< 310	≤ 7.90– 0.005409H	≤ 15.0
	≥ 310 and < 820	≤ 7.08-0.002752H	≤ 15.0
	≥ 4,000	≤ 4.82	≤ 15.0
Remote Condensing Units (w/out remote compressor)	< 800	≤ 7.76– 0.00464H	≤ 15.0
	≥ 800 and < 4,000	≤ 4.05	≤ 15.0
Remote Condensing Units (w/ remote compressor)	< 800	≤ 7.76– 0.00464H	≤ 15.0
	≥ 800 and < 4,000	≤ 4.05	≤ 15.0
Self-Contained Units	< 200	≤ 12.37–0.0261H	≤ 15.0
	≥ 200 and < 700	≤ 8.24-0.005429H	≤ 15.0
	≥ 700 and < 4,000	≤ 4.44	≤ 15.0

D.5.10.3. Estimated Useful Life (EUL)

According to DEER 2011, the average commercial ice maker will have a measure life of 10 years.

D.5.10.4. Energy and Demand Savings

Energy savings and demand reductions for commercial ice makers are based on the energy consumption from the harvesting of ice, either in batches or continuously. The following subsections outline deemed calculations for energy savings and demand reductions, respectively.

D.5.10.4.1. Calculations of Deemed Savings

Annual electric savings are calculated by determining the energy consumed for baseline ice makers compared against the energy consumed by qualifying ENERGY STAR® product using the harvest rate of the more efficient unit.

The following two equations show how energy savings and demand reductions can be calculated, respectively:

$$\Delta kWh = \frac{\left(kWh_{base,per\ 100\ lb} - kWh_{ee,per\ 100\ lb}\right)}{100} \times DC \times H \times 365$$

$$\Delta kW = \left(\frac{\Delta kWh}{HRS}\right) \times CF$$

Where:

$kWh_{base,per\ 100\ lb}$ = calculated on the harvest rate and type of ice machine from the Federal Minimum Energy Consumption Rate relationships in Table D-128 and Table D-129

$kWh_{ee,per\ 100\ lb}$ = Qualifying energy efficient model consumption found in the AHRI directory of certified products by model information.

100 = conversion factor to convert $kWh_{base,per\ 100\ lb}$ and $kWh_{ee,per\ 100\ lb}$ into maximum kWh consumption per pound of ice

DC = Duty Cycle of the ice maker representing the percentage of time the ice machine is making ice = 0.75

H = Harvest Rate (lbs. of ice made per day)

365 = days per year

HRS = Annual operating hours = 365 * 24 = 8,760 hours/year

CF = 1.0

For example, the annual energy savings and demand reductions for a batch type IMH commercial ice maker with an ice harvest rate *(H)* of 550 lbs. of ice per day and a consumption rate of kWh/100 lbs. ice of 4.45 are calculated as:

$$\Delta kWh = \frac{((7.05 - 0.0025 \times 550) - 4.45)}{100} \times 0.75 \times 550 \times 365 = 1{,}844\ kWh$$

$$\Delta kW = \left(\frac{1{,}844\ kWh}{8{,}760\ hr/yr}\right) \times 1.0 = 0.2105\ kW$$

D.5.10.5. Incremental Cost[594]

Ice Harvest Rate (H)	*Incremental Cost*
100-200 lb. ice maker	$296
201-300 lb. ice maker	$312
301-400 lb. ice maker	$559
401-500 lb. ice maker	$981
501-1000 lb. ice maker	$1,485
1001-1500 lb. ice maker	$1,821
<1500 lb. ice maker	$2,194

D.5.10.6. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. Thus, savings are calculated using ENERGY STAR default values. If this measure is added to Energy Smart programs, the evaluation should include a review of actual efficiency levels and costs of units rebated in the program.

Deemed parameters should be updated whenever DOE standards or other applicable codes warrant it.

[594] These values are from electronic work papers prepared in support of San Diego Gas & Electric's "Application for Approval of Electric and Gas Energy Efficiency Programs and Budgets for Years 2009-2011", SDGE, March 2, 2009. https://www.sdge.com/node/709

D.6. Commercial Lighting

D.6.1. Commercial Lighting Efficiency

D.6.1.1. Measure Description

A variety of high-efficiency fixtures, ballasts and lamps exist in the market today, producing the same lighting level (in lumens) as their standard-efficiency counterparts while consuming less electricity. This measure provides energy and demand savings calculations for the replacement of commercial lighting equipment with energy efficient lamps or fixtures. The operating hours and demand factors for the different building types listed in this measure are based on a wide array of information available in the market.

D.6.1.2. Baseline & Efficiency Standard

The following sections explain the various codes, standards, and required processes to establish the applicability of the Lighting Efficiency savings calculation method.

D.6.1.1. Deemed Savings

Due to the myriad of possible baseline lighting configurations, efficient configurations and facility parameters that contribute to a commercial lighting savings calculation, the TPE has opted to not include deemed savings per-fixture. Such a value would require too many assumptions and is likely to be too in accurate to provide a fixed estimate. If the needed data cannot be collected by program implementers, then the project in question is ineligible for savings. The data requested to calculate deemed savings is consistent with what program implementers have historically collected in implementing Energy Smart programs and align with industry best practices for deemed savings for commercial lighting.

D.6.1.1.1. State Commercial Energy Codes

Louisiana's state commercial energy code recognizes ASHRAE 90.1-2007[595] for commercial structures. These standards specify the maximum lighting power densities (LPDs) by building type (building area method) and interior space type (space-by-space method). LPDs apply to all new construction and major renovation projects. The ASHRAE 90.1-2007 LPDs for various building types are outlined in Appendix F. Agricultural lighting for animals will utilize recognized industry standards unique to the requirements of that animal to determine the LPD for the building housing those animals.

D.6.1.1.2. Retrofit Baseline Summary

For all retrofit projects, the baseline is the current federal efficacy standard. If the replacement system is a T8, then it must meet Consortium for Energy Efficiency (CEE)

[595] Any references to any versions of this standard refer to the American National Standards Institute (ANSI) /American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)/Illuminating Engineering Society of North America (IESNA) Standard 90.1

specification requirements for High Performance and Reduced Wattage T8 systems. Other high-performance systems, including but not limited to T5 and LED systems, are allowed. T12s are no longer an eligible baseline technology.

D.6.1.1.3. Federal Efficacy Standards

The Energy Independence and Security Act (EISA) of 2007 mandates minimum efficacy standards for general service incandescent lamps, modified spectrum general service incandescent lamps, incandescent reflector lamps, fluorescent lamps and metal halide lamps.

Effective January 1, 2010, EISA increased minimum ballast efficacy factors and established pulse-start metal halides (PSMHs) as the new industry standard baseline for the metal halide technology ($\leq$ 500 W). New construction projects must use PSMHs in metal halide applications.

Starting in 2012, baseline wattages for general service incandescent lamps (GSILs) should not exceed values specified by EISA. For convenience, Table D-132 provides the lumens and wattages required to meet EISA standards for incandescent lamps.

Table D-132: New Maximum Wattages for General Service Incandescent Lamps, 2012-2014

Old Standard Incandescent Wattage	New Maximum Wattage (EISA 2007)	Rated Lumens	Effective Date[596]
100	72	1490 - 2600	6/1/2012
75	53	1050 - 1489	6/1/2013
60	43	750 - 1049	6/1/2014
40	29	310 – 749	6/1/2014

The Energy Policy Act (EPAct) of 2005 and EISA of 2007 are two energy legislative rulings enacted to establish energy reduction targets for the United States. On July 14, 2009, the Department of Energy published a final rule for energy conservation standards for general service fluorescent lamps (GSFLs). These standards are shown in Table D-133. As a result of this rule, all GSFLs manufactured in the United States, or imported for sale into the United States on or after July 14, 2012 (three years from the ruling date) must meet new, more stringent efficacy standards (measured in lumens per watt, LPW).

[596] Adjusted from January to June assuming continued market availability for a period of 6 months after the standard effective date.

Table D-133: Lighting Efficiency – Current Federal Efficiency Standards for GSFLs

Lamp Type	Nominal Lamp Wattage	Minimum Color Rendering Index (CRI)	Minimum Average Lamp Efficacy (Lumens/Watt, or LPW)
4-foot Medium Bi-Pin	> 35W ≤ 35 W	69 45	75.0 75.0
2-foot U-Shaped	> 35W ≤ 35W	69 45	68.0 64.0
8-foot Slimline	> 65W ≤ 65W	69 45	80.0 80.0
8-foot High Output	> 100W ≤ 100W	69 45	80.0 80.0

Facilities with 4-foot and 8-foot T12s or with 2-foot U-Shaped T12s are still eligible to participate in lighting retrofit projects, but an assumed electronic T8 baseline should be used in place of the existing T12 equipment. These T12 fixtures will remain in the standard wattage table with the label “T12 (T8 baseline)” and will include adjusted wattages assumptions consistent with a T8 fixture with an equivalent length and lamp count. T12 fixtures not specified above will remain an eligible baseline technology.

Table D-134: Adjusted Baseline Wattages for T12 Equipment

T12 Length	*Lamp Count*	*Revised Lamp Wattage*	*Revised System Wattage*
48 inch- Std, HO, and VHO (4 feet)	1	32	31
	2	32	58
	3	32	85
	4	32	112
	6	32	170
	8	32	224
96 inch-Std (8 feet) 60/75W	1	59	69
	2	59	110
	3	59	179
	4	59	219
	6	59	330
	8	59	438*
96 inch-HO and VHO (8 feet) 95/110W	1	86	101
	2	86	160
	3	86	261
	4	86	319
	6	86	481
	8	86	638
2 ft. U-Tube	1	32	32
	2	32	60
	3	32	89
* 8 lamp fixture wattage approximated by doubling 4 lamp fixture wattage.			
Key: HO = high output, VHO = very high output			

D.6.1.1.4. Fixture Qualification Process – High Performance and Reduced Wattage T-8 Equipment:

CEE develops and maintains energy specifications for High Performance and Reduced Wattage T8 equipment. CEE high performance and reduced wattage T8 specifications can be found at:

1) http://www.cee1.org/com/com-lt/com-lt-specs.pdf (High Performance products)
2) http://www.cee1.org/com/com-lt/lw-spec.pdf (Reduced Wattage products)

CEE compiles a list of approved lamps and ballasts for T8 systems that are eligible for incentives for retrofits which is available for download on CEE's website at http://library.cee1.org/content/commercial-lighting-qualifying-products-lists.

D.6.1.1.5. Fixture Qualification Process – CFL and LED Products:

CFL and LED products must be pre-qualified under one of the following options:

1) Product is on the ENERGY STAR® Qualified Product List or ENERGY STAR® Qualified Light Fixtures Product List (http://www.energystar.gov)
2) Product is on the Northeast Energy Efficiency Partnerships (NEEP) DesignLights Consortium™ (DLC) Qualified Products Listing (www.designlights.org)
3) Exceptions to the ENERGY STAR® and/or DLC requirements are allowed for unlisted lamps and fixtures that have already been submitted to either ENERGY STAR® or DLC for approval. If the lamp or fixture does not achieve approval within the AR DSM program year, however, then the lamp or fixture must immediately be withdrawn from the program. If withdrawn, savings may be claimed up to the point of withdrawal from the program. For Agricultural uses where the fixture is designed for animal use, if an LED bulb does not meet ENERGY STAR® and/or DLC requirements, the bulb can be utilized if a thorough review of the bulb is conducted and verified by the TPE.

D.6.1.2. Input Wattages

Input wattages for pre-retrofit and qualifying fixtures are included in the Standard Fixture Wattage Table (Appendix E). This is a relatively comprehensive list of both old and new lighting technologies that could be expected for inclusion in a project. If there are fixtures identified that are not included in this table, those fixtures should be submitted to the Independent Evaluation Monitor (IEM) for review and incorporation into subsequent TRM updates. Interim approval may be made for certain fixtures at the discretion of the IEM. However, there may be eligible products that are not on the list. If a product is not on the list, then manufacturer's data should be reviewed prior to accepting the product into a program. LED products should be approved by DLC or ENERGY STAR® before being recognized as an eligible product.

D.6.1.3. Estimated Useful Life (EUL)

Table D-135: Estimated Useful Life by Lamp Type

Lamp Type	***EUL (years)***	***Source***[597]
Halogen	2.0	Based upon 5,000-hour manufacturer rated life and weighted-average 3,380 annual operating hours from Navigant U.S. Lighting Study. Rated life values assume the use of energy-efficient Halogen Infrared (IR) products.
High Intensity Discharge (HID)	16.0	Based upon 50,000 hour manufacturer rated life and weighted-average 3,205 annual operating hours from Navigant U.S. Lighting Study.
Integrated-Ballast Cold-Cathode Fluorescent Lamps (CCFL)	5.0	Based upon 25,000 hour manufacturer rated life and weighted-average 5,493 annual operating hours from Navigant U.S. Lighting Study.
Integrated-Ballast Compact Fluorescent Lamps (CFL)	2.025	Based upon 8,000 hour manufacturer rated life and weighted-average 3,253 annual operating hours from Navigant U.S. Lighting Study.
Integrated-Ballast LED Lamps	9.0	Based on 30,000 hour manufacturer rated life and weighted-average 3,260 annual operating hours from Navigant U.S. Lighting Study.
Light Emitting Diode (LED)	15.0	Based upon 50,000 hour manufacturer rated life and weighted-average 3,260 annual operating hours from Navigant U.S. Lighting Study.
Linear Fluorescents (T5, T8)	16.0	Based upon 50,000 hour manufacturer rated life and weighted-average 3,211 annual operating hours from Navigant U.S. Lighting Study.
Modular CFL and CCFL	16.0	Based upon 60,000 hour manufacturer rated life and weighted-average 3,251 annual operating hours from Navigant U.S. Lighting Study.

[597] Navigant Consulting, "U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate, Final Report." U.S. DOE. September 2002.

D.6.1.4. Calculation of Deemed Savings

D.6.1.4.1. New Construction:

$$kW_{savings} = \left(\left(SF \times \frac{LPD}{1000}\right) - \sum\left(\left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{post}\right)\right) \times CF \times IEF_D$$

$$kWh_{savings} = \left(\left(SF \times \frac{LPD}{1000}\right) - \sum\left(\left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{post}\right)\right) \times AOH \times IEF_E$$

Where:

SF = Total affected square footage of the new construction facility

LPD = Maximum allowable power density by building type (W/ft^2) (See Appendix B)

$N_{fixt(i),post}$ = Post-retrofit # of fixtures of type i

$W_{fixt(i),post}$ = Rated wattage of post-retrofit fixtures of type i (Appendix E)

CF = Peak demand coincidence factor (Table D-137)

AOH = Annual operating hours for specified building type (Table D-137)

IEF_D = Interactive effects factor for demand savings (Table D-138)

IEF_E = Interactive effects factor for energy savings (Table D-138)

D.6.1.4.2. Retrofit with no existing controls:

$$kW_{savings} = \sum\left(\left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{pre} - \left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{post}\right) \times CF \times IEF_D$$

$$kWh_{savings} = \sum\left(\left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{pre} - \left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{post}\right) \times AOH \times IEF_E$$

D.6.1.4.3. Retrofit with existing controls:

Note: For lighting systems with existing controls, no additional control savings should be claimed with the savings specified by the equations below.

$$kW_{savings} = \sum\left(\left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{pre} - \left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{post}\right) \times IEF_D \times CF_{controls}$$

$$kWh_{savings} = \sum\left(\left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{pre} - \left[N_{fixt(i)} \times \frac{W_{fixt(i)}}{1000}\right]_{post}\right) \times IEF_E \times AOH \times PAF$$

Where:

$N_{fixt(i),pre}$ = Pre-retrofit number of fixtures of type i

$N_{fixt(i),post}$ = Post-retrofit number of fixtures of type i

$W_{fixt(i),pre}$ = Rated wattage of pre-retrofit fixtures of type i (Appendix E)

$W_{fixt(i),post}$ = Rated wattage of post-retrofit fixtures of type i (Appendix E)

CF = Peak demand coincidence factor (Table D-137)

$CF_{controls}$ = Controls peak demand coincidence factor = 0.26[598]

AOH = Annual operating hours for specified building type (Table D-137)

PAF = Power adjustment factor for specified control type (Table D-145)

IEF_D = Interactive effects factor for demand savings (Table D-138)

IEF_E = Interactive effects factor for energy savings (Table D-138)

D.6.1.5. Operating Hours & Coincidence Factors (CF)

If the annual operating hours and/or CF for the specified building are not known, use the deemed average annual hours of operation and/or peak demand CF from Table D-137.

Table D-136 summarizes the general transferability ratings for the lighting end-use. Due to the low variability of schedules and weather for both indoor and outdoor lighting, there is a high degree of data transferability across regions and it is appropriate to assume very similar annual operating hours across different regions.[599] To the extent that utility system peak periods are similar, it is also appropriate to assume very similar peak CFs across different regions.

Table D-136: Transferability of Data across Geographic Regions

Analysis Group	***Schedule Variability***	***Weather Variability***	***Transferability Rating***
Lighting – Exterior	Low	Low	High
Lighting – Interior	Low	Low	High

Operating hours are the number of hours that a particular equipment type is in use over the course of a year. For the purpose of these recommendations, raw building lighting operating hour data were adjusted by Frontier Associates according to the percentage of

[598] RLW Analytics, *"2005 Coincidence Factor Study,"* Connecticut Energy Conservation Management Board. January 4, 2007. Default value applicable to all building types. This coincidence factor is a combination of the savings factor and peak coincidence factor.

[599] KEMA. *End-Use Load Data Update Project Final Report: Phase 1: Cataloguing Available End-Use and Efficiency Measure Load Data*. 2009. Prepared for the Northwest Power and Conservation Council and Northeast Energy Efficiency Partnerships, November.

wattage consumed by each space within a building. Subsequently, weighted average operating hours (AOH) were developed for a range of building types.

The CF for lighting is the ratio of the lighting kW demand during the utility's peak period (New Orleans does not have a specific peak period definition, and CF values are assumed to reflect peak loads of similar utilities) to the connected lighting kW ($\sum(N_i \times W_i / 1000)$ as defined above. Other issues are automatically accounted for, such as diversity and load factor. A portion of the CF values were arrived at through secondary research. In the cases where acceptable values were not available through other sources, Frontier Associates calculated values comprised of CF and building operating hour data available for the types of building spaces that would likely be found within that building type.

Deemed annual operating hours from the Arkansas TRM 6.0 were used as a basis for New Orleans AOH. These hours were originally developed by Frontier Associates for the AR TRM. The TPE used these values in conjunction with on-site monitoring from facility types commonly found New Orleans commercial lighting program participant populations. Direct monitoring data was collected from 210 loggers placed in 59 New Orleans and other major Louisiana utility territories. A total of (14) facility types received updated hours, and (10) new generic space types common in New Orleans area-projects were created:

Table D-137: Annual Operating Hours (AOH) and Coincidence Factors (CF)[600]

Facility or Space Type	AOH	CF
Leisure Dining: Bar Area	2,676	0.81
Corridor/Hallway/Stairwell	5,233	0.90
Education: College/University	3,577	0.69
Education: K-12	2,333	0.47
Exterior	4,319	-
Food Sales: 24-Hour Supermarket	6,900	0.95
Food Sales: Non-24-Hour Supermarket	2,058	0.95
Food Service: Fast Food	6,473	0.81
Food Service: Sit-Down Restaurant	4,731	0.81
Health Care: In-Patient	4,019	0.78
Health Care: Nursing Home	4,271	0.78
Health Care: Out-Patient	3,386	0.77
Convenience Store (non-24 hour)	4,245	0.90
Lodging (Hotel/Motel/Dorm): Common Areas	4,127	0.82
Lodging (Hotel/Motel/Dorm): Room	3,370	0.25
Manufacturing	5,740	0.73
Multi-family Housing: Common Areas	5,703	0.87
Non-Warehouse Storage (Generic)	4,207	0.77
Office	5,159	0.77
Office (attached to other facility)	4,728	0.77
Parking Structure	7,884	1.00
Public Assembly	2,638	0.56
Public Order and Safety	3,472	0.75
Religious Gathering	3,174	0.53
Restroom (Generic)	3,516	0.90
Retail: Enclosed Mall	4,813	0.93
Retail: Freestanding	3,515	0.90
Retail: Other	4,312	0.90
Retail: Strip Mall	3,965	0.90
Service: Excluding Food	3,406	0.90
Warehouse: Non-Refrigerated	2,417	0.77
Warehouse: Refrigerated	3,798	0.84

[600] Unless otherwise noted, deemed AOH and CF values are based on Frontier Associates on behalf of Electric Utility Marketing Managers of Texas (EUMMOT). “Petition to Revise Existing Measurement & Verification Guidelines for Lighting Measures for Energy Efficiency Programs: Docket No. 39146.” Public Utility Commission of Texas. Approved June 6, 2011. http://interchange.puc.state.tx.us/WebApp/Interchange/application/dbapps/filings/pgSearch.asp

D.6.1.6. Interactive Effects

Lighting in air conditioned and refrigerated spaces adds heat to the space, increasing the cooling requirement during the cooling season and decreasing the heating requirement during the heating season. The decrease in waste heat from lighting mitigates these effects, thus reducing electricity used for cooling and increasing electricity or gas used for heating.

Deemed interactive effects factors for both demand and energy savings are presented in Table D-138. These factors represent the percentage increase or decrease in energy savings for the refrigeration system's electric load attributed to the heat dissipated by the more efficient lighting system. For example, a factor of 1.20 indicates a 20% savings. The methodology for applying these Interactive Effects Factors to calculate savings is discussed in the Calculation of Deemed Savings section.

A detailed description of the derivation of interactive effects is available in Appendix I.

Table D-138: Commercial Conditioned and Refrigerated Space Interactive Effects Factors

<table>
<tr><th>Building Type</th><th>Temperature Description</th><th>Heating Type</th><th>IEF_D</th><th>IEF_E</th></tr>
<tr><td rowspan="6">All building types (Except Outdoor & Parking Structure)</td><td rowspan="4">Air Conditioned Space – Normal Temps. (> 41°F)</td><td>Gas</td><td rowspan="4">1.20</td><td>1.09</td></tr>
<tr><td>Electric Resistance</td><td>0.87</td></tr>
<tr><td>Heat Pump</td><td>1.02</td></tr>
<tr><td>Heating Unknown [601]</td><td>0.98</td></tr>
<tr><td>Refrigerated Space – Med. Temps. (33-41°F)</td><td>All</td><td>1.25</td><td>1.25</td></tr>
<tr><td>Refrigerated Space – Low Temps. (-10-10°F)</td><td>All</td><td>1.30</td><td>1.30</td></tr>
</table>

D.6.1.7. Incremental Costs

Incremental costs by lighting category are as follows.

D.6.1.7.1. Commercial CFLs

Incremental costs are[602]:

- < 2,600 Lumens: $1.20
- Over 2,600 Lumens: $5

D.6.1.7.2. High Performance and Reduced Wattage T8s

Incremental costs are detailed in Table D-139[603]:

601 These values should be used for programs where heat type cannot be determined.

602 Illinois TRM

603 Illinois TRM

Table D-139: T8 Linear Fluorescent Incremental Costs

EE Measure	Watts	Baseline	Incremental Cost
4-lamp HPT8 High-bay	128	200W Pulse Start MH	$75
4-lamp HPT8 High-bay	128	250W Pulse Start MH	$75
6-lamp HPT8 High-bay	192	320W Pulse Start MH	$75
6-lamp HPT8 High-bay	192	400W Pulse Start MH	$75
8-lamp HPT8 High-bay	256	320W Pulse Start MH	$75
8-lamp HPT8 High-bay	256	400W Pulse Start MH	$75
1-lamp HPT8 – 32W	32	1-lamp standard F328- Electronic ballast	$15
1-lamp HPT8 – 28W	28	1-lamp standard F328- Electronic ballast	$15
1-lamp HPT8 – 25W	25	1-lamp standard F328- Electronic ballast	$15
2-lamp HPT8 – 32W	64	2-lamp standard F328- Electronic ballast	$18
2-lamp HPT8 – 28W	56	2-lamp standard F328- Electronic ballast	$18
2-lamp HPT8 – 25W	50	2-lamp standard F328- Electronic ballast	$18
3-lamp HPT8 – 32W	96	3-lamp standard F328- Electronic ballast	$20
3-lamp HPT8 – 28W	84	3-lamp standard F328- Electronic ballast	$20
3-lamp HPT8 – 25W	75	3-lamp standard F328- Electronic ballast	$20
4-lamp HPT8 – 32W	128	4-lamp standard F328- Electronic ballast	$23
4-lamp HPT8 – 28W	112	4-lamp standard F328- Electronic ballast	$23
4-lamp HPT8 – 25W	100	4-lamp standard F328- Electronic ballast	$23
2-lamp HPT8 Troffer	64	3-lamp standard F328- Electronic ballast	$100
RW T8-F28 Lamp	28	F32 T8 Standard lamp	$2
RW T8-F28 Extra Life Lamp	28	F32 T8 Standard lamp	$2
RW T8-F32/25W Lamp	25	F32 T8 Standard lamp	$2
RW T8-F32/25 Extra Life Lamp	285	F32 T8 Standard lamp	$2
RWT8 F17T8 Lamp - 2 ft.	16	F17 T8 Standard lamp – 2 ft.	$2
RWT8 F25T8 Lamp - 3 ft.	23	F25 T8 Standard lamp – 3 ft.	$2
RWT8 F30T8 Lamp - 6' Utube	30	F32 T8 Standard Utube	$2
RWT8 F29T8 Lamp - Utube	29	F32 T8 Standard Utube	$2
RWT8 F96T8 Lamp - 8 ft.	65	F96 T8 Standard lamp – 8 ft.	$2

D.6.1.7.3. T5 Linear Fluorescent Fixtures

Table D-140: T5 Linear Fluorescent Incremental Costs

EE Measure	Watts	Baseline	Incremental Cost
2-lamp T5 High-bay	180	200W Pulse Start MH	$100
3-lamp T5 High-bay	180	200W Pulse Start MH	$100
4-lamp T5 High-bay	240	320W Pulse Start MH	$100
6- lamp T5 High-bay	192	320W Pulse Start MH	$100
1-lamp T5 Troffer	32	3-lamp T8	$40
2-lamp T5 Troffer	64	3-lamp T8	$80
1-lamp T5 Industrial/Strip	32	3-lamp T8	$30
2- lamp T5 Industrial/Strip	64	3-lamp T8	$60
3- lamp T5 Industrial/Strip	96	3-lamp T8	$90
4- lamp T5 Industrial/Strip	187	3-lamp T8	$120
1-lamp T5 Indirect	32	3-lamp T8	$30
2-lamp T5 Indirect	64	3-lamp T8	$60

D.6.1.7.4. LEDs

Table D-141: Omnidirectional LED Incremental Costs

LED Measure Description	***LED Lamp Cost***	***Baseline Cost (EISA 2012-2014, EISA 2020)***	***Incremental Cost (EISA 2012-2014, EISA 2020)***
LED Screw and Pin-based Bulbs, Omnidirectional, <10W	$30.00	$0.34 ($1.25, $2.50)	$29.66 ($28.75, $27.50)
LED Screw and Pin-based Bulbs, Omnidirectional, >=10W	$40.00	$0.34 ($1.25, $2.50)	$39.66 ($38.75, $37.50)
LED Screw and Pin-based Bulbs, Decorative	$30.00	$1.00	$29.00

Table D-142: LED Incremental Costs[604]

LED Category	EE Measure	Incremental Cost
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	$27
LED Interior Directional	LED Track Lighting	$59
	LED Wall-Wash Fixtures	$59
LED Display Case	LED Display Case Light Fixture	$11/ft.
	LED Undercabinet Shelf-Mounted Task Light Fixtures	$11/ft.
	LED Refrigerated/Freezer Case light	$11/ft.
LED Linear Replacement Lamps	LED 4' Linear Replacement Lamp	$13
	LED 2' Linear Replacement Lamp	$13
LED Troffers	LED 2x2 Recessed Light Fixture, 2,000-3,500 Lumens	$48
	LED 2x2 Recessed Light Fixture, 3,501-5,000 Lumens	$91
	LED 2x4 Recessed Light Fixture, 3,000-4,500 Lumens	$62
	LED 2x4 Recessed Light Fixture, 4,501-6,000 Lumens	$99
	LED 2x4 Recessed Light Fixture, 6,001-7,500 Lumens	$150
	LED 1x4 Recessed Light Fixture, 3,001-4,500 Lumens	$36
	LED 1x4 Recessed Light Fixture, 4,401-6,000 Lumens	$130
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <=3,000 Lumens	$54
	LED Surface & Suspended Linear Fixture, 3,001-4,500 Lumens	$104
	LED Surface & Suspended Linear Fixture, 4,501-6,000 Lumens	$158
	LED Surface & Suspended Linear Fixture, 6,001-7,500 Lumens	$215
	LED Surface & Suspended Linear Fixture, >7,500 Lumens	$374
LED Low Bay & High Bay Fixtures	LED Low-Bay Fixtures, <= 10,000 Lumens	$191
	LED High-Bay Fixtures, 10,001-15,000 Lumens	$331
	LED High-Bay Fixtures, 15,001-20,000 Lumens	$482
	LED High-Bay Fixtures, > 20,000 Lumens	$818
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 Lumens	$33
	LED Ag Interior Fixtures, 2,001-4,000 Lumens	$54
	LED Ag Interior Fixtures, 4,001-6,000 Lumens	$125
	LED Ag Interior Fixtures, 6,001-8,000 Lumens	$190
	LED Ag Interior Fixtures, 8,001-12,000 Lumens	$298
	LED Ag Interior Fixtures, 12,001-16,000 Lumens	$450
	LED Ag Interior Fixtures, 16,001-20,000 Lumens	$595
	LED Ag Interior Fixtures, > ,000 Lumens	$998
LED Exterior Fixtures	LED Exterior Fixtures, <=5,000 Lumens	$190
	LED Exterior Fixtures, 5,001-10,000 Lumens	$287
	LED Exterior Fixtures, 10,001-15,000 Lumens	$391
	LED Exterior Fixtures, > 15,000 Lumens	$793

[604] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists alongside past Efficiency Vermont projects and PGE refrigerated case study. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment. Efficient cost data comes from 2012 DOE "Energy Savings Potential of Solid-State Lighting in General Illumination Applications", Table A.1. See "LED Lighting Systems TRM Reference Tables.xlsx" for more information and specific product links.

D.6.1.8. Future Studies

This measure category constitutes over 90% of C&I savings historically in Energy Smart. As a result, this category should be a primary focus of EM&V research. The TPE recommends the following:

- Conduct metering studies for commercial facilities not captured in EM&V to-date.
- Conduct a cost study to update incremental costs to reflect New Orleans prices, sales tax rates, and labor costs.
- Conduct focused metering for lighting that is not listed in Energy Start or CEE lists.
- Conduct a market assessment for advanced lighting controls; mature lighting programs have begun further incorporation of Wi-Fi-enabled control schemes where lighting is incorporated into the Energy Management System (EMS). The TPE recommends a market assessment for advanced lighting control adoption in New Orleans.
- Conduct preliminary research to assess whether certain lighting categories would be better-served with a midstream program approach.

D.6.2. Lighting Controls

D.6.2.1. Measure Description

Automatic lighting controls save energy by switching off or dimming lights when they are not necessary. Some lighting control techniques, such as using photocell controls, can be coupled with a variety of control strategies, including daylighting controls, occupancy controls, timer controls, and time clocks.

D.6.2.1.1. Stepped Lighting Control Systems

When switching systems are used with entire circuits of lights, as opposed to individual light fixtures, the control protocol is usually described in terms of steps, with each "step" referring to a percentage of full lighting power.

D.6.2.1.2. Continuous Dimming Control Systems

Continuous dimming control systems are designed to adjust electric lighting to maintain a designated light level. Continuous dimming systems eliminate distracting and abrupt changes in light levels, provide appropriate light levels at all times, and provide an increased range of available light level. Cost is the major disadvantage of this control.

D.6.2.1.3. Occupancy Sensors

Occupancy sensors use motion detection to control lights in response to the presence or absence of occupants in a space. Many different varieties of sensors are available, including passive infrared (PIR), Ultrasound detecting, dual-technology, and integral occupancy sensors. Occupancy sensors are most effective in spaces with sporadic or unpredictable occupancy levels.

D.6.2.1.4. Daylighting

Daylighting controls switch or dim electric lights in response to the presence or absence of daylight illumination in the space. Advanced daylighting controls incorporate occupancy and daylighting sensors into the same control.

D.6.2.2. Baseline and Efficiency Standards

IECC 2003 (Section 805.2) and IECC 2009 (Section 505.1) specify the conditions under which light reduction and automatic controls are mandatory for new construction and affected retrofit projects. See the Measure Baseline section under the lighting efficiency measure for a discussion of updated lighting fixture wattages.

There are no minimum efficiency requirements for lighting controls.

D.6.2.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life (EUL) is eight years for Daylighting Sensors and eight years for Occupancy Sensors.

D.6.2.4. Deemed Savings

Due to the myriad of possible lighting configurations upon which occupancy sensors may be installed, the TPE has opted to not include deemed savings per-control. Such a value would require too many assumptions and is likely to be too inaccurate to provide a fixed estimate. If the needed data cannot be collected by program implementers, then the project in question is ineligible for savings. The data requested to calculate deemed savings is consistent with what program implementers have historically collected in implementing Energy Smart programs and align with industry best practices for deemed savings for commercial lighting.

D.6.2.5. Calculation of Deemed Savings

D.6.2.5.1. *Measure/Technology Review*

There have been many in-depth studies performed on the energy savings associated with occupancy and daylighting controls. Research by various organizations – including the Illuminating Engineering Society (IES), Canada National Research Council (CNRC), New Buildings Institute (NBI), Lighting Research Center (LRC) and multiple utilities – was included in this review. A summary of the findings of these reports are located in Table D-143 and Table D-144.

Table D-143: Lighting Controls – Energy Saving Estimates for Occupancy Sensors

Location	***IES[605]***	***CNRC[606]***	***NBI[607]***	***LRC[608]***
Break Room	22%	-	-	-
Classroom	45%	63%	25%	-
Conference Room	43%	-	-	-
Corridor	-	24%	-	-
Office	32%	44%	35-45%	43%
Restroom	41%	-	-	-

[605] IES HB-9-2000. "Illuminating Engineering Society Lighting Handbook 9th Edition". 2000.

[606] Canada National Research Center, "Energy Savings from Photosensors and Occupant Sensors/Wall Switches". September 2009.

[607] New Buildings Institute. 2010. http://buildings.newbuildings.org/.

[608] Lighting Research Center (LRC), Solid State Lighting Program. http://www.lrc.rpi.edu/researchareas/leds.asp.

Table D-144: Lighting Controls – Energy Saving Estimates for Daylighting Sensors

Location	CNRC	NBI	SoCal Edison[609]	LRC
Classroom	16%	40%	-	-
Corridor	25%	-	-	-
Office	22%	35-40%	74%	24-59%
Grocery Stores	-	40%	-	-
Big Box Retail	-	60%	-	-

Lighting energy savings can be calculated using the following formula. The kWh savings for each combination of fixture type, fixture location, building type, and refrigeration type must be calculated separately:

$$kW_{savings} = N_{fixt} \times \frac{W_{fixt}}{1000} \times CF \times IEF_D$$

$$kWh_{savings} = N_{fixt} \times \frac{W_{fixt}}{1000} \times (1 - PAF) \times AOH \times IEF_E$$

Where:

N_{fixt} = Number of fixtures

W_{fixt} = Rated wattage of post-retrofit fixtures (Appendix E)

Note: If the fixture was retrofitted, use the installed fixture wattage; if fixture was not retrofitted, use the existing fixture wattage

PAF = Stipulated power adjustment factor based on control type (Table D-145)

CF = Peak demand coincidence factor = 0.26[610]

AOH = Annual operating hours for specified building type (Table D-137)

IEF_D = Interactive effects factor for demand savings (Table D-138)

IEF_E = Interactive effects factor for energy savings (Table D-138)

[609] Southern California Edison, "Energy Design Resources: Design Brief Lighting Controls". February 2000.

[610] RLW Analytics, "*2005 Coincidence Factor Study,*" Connecticut Energy Conservation Management Board. January 4, 2007. Default value applicable to all building types. This coincidence factor is a combination of the savings factor and peak coincidence factor.

Table D-145: Lighting Controls – Power Adjustment Factors[611]

Control Type	**Power Adjustment Factor (PAF)**
No controls measures	1.00
Daylighting Control – Continuous Dimming	0.70
Daylighting Control – Multiple Step Dimming	0.80
Daylighting Control – ON/OFF (Indoor)	0.90
Daylighting Control – ON/OFF (Outdoor) 612	1.00
Occupancy Sensor	0.70
Occupancy Sensor w/ Daylighting Control – Continuous Dimming	0.60
Occupancy Sensor w/ Daylighting Control – Multiple Step Dimming	0.65
Occupancy Sensor w/ Daylighting Control – ON/OFF	0.65

D.6.2.6. Incremental Costs

Incremental costs for lighting controls should use the full project cost. If not available, use the table below.

[611] ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

[612] ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

Table D-146: Lighting Controls – Incremental Costs

Control Type	***Power Adjustment Factor (PAF)***
Daylighting Control – Continuous Dimming	$274[613]
Daylighting Control – Multiple Step Dimming	$274
Daylighting Control – ON/OFF (Indoor)	$274
Daylighting Control – ON/OFF (Outdoor) 614	$274
Occupancy Sensor	$42[615]
Occupancy Sensor w/ Daylighting Control – Continuous Dimming	$316
Occupancy Sensor w/ Daylighting Control – Multiple Step Dimming	$316
Occupancy Sensor w/ Daylighting Control – ON/OFF	$316

[613] Consistent with the Multi-level Fixture measure with reference to Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009. Also consistent with field experience of about $250 per fixture and $25 install labor.

[614] ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

[615] DEER 2014

D.6.3. Bi-Level Lighting Fixtures in Parking Garages

D.6.3.1. Measure Description

Automated bi-level lighting fixture with motion sensors installed in a parking garage. The fixture provides lower levels of lighting during unoccupied periods. This measure covers savings from operational changes. Savings are fixture operation only. Retrofit savings from fixture replacement should be calculated using section D.6.1 Commercial Lighting Efficiency.

D.6.3.2. Baseline and Efficiency Standards

Savings for retrofit only. The baseline equipment is assumed to be an uncontrolled lighting system operating continuously in an unconditioned space. Parking garage lighting zones must be controlled by a device that reduces power by a minimum of 30% after 20 minutes of vacancy[616]. Lighting must comply with IECC 2009 guidelines and must otherwise comply with program eligibility requirements.

D.6.3.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 8 years, which is consistent with the DEER 2014 EUL for occupancy and daylighting sensors.

D.6.3.4. Percent Time in Reduced Power State

The average percentage of time spent in high (occupied) and low-power (unoccupied) states was derived from an analysis of metered studies of commercial bi-level retrofit projects conducted for the DOE[617], and case studies by the California Energy Commission[618].

Table D-147: Estimated Percent Time in "Low Power" (unoccupied) State

Factor	***DOE Study***	***CEC Case Study 1***	***CEC Case Study 2***	***CEC Case Study 3***	***Value used for New Orleans***
Percent time luminaries operate in low power or "dimmed" mode	45%	60%	52%	47%	51%

[616] ASHRAE 90.1

[617] PG&E Emerging Technologies Program, 2009. "Application Assessment of Bi-Level LED Parking Lot Lighting." https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_raleys.pdf

[618] CEC PIER Buildings Program, "Bi-level LED Parking Garage Luminaries." https://cltc.ucdavis.edu/sites/default/files/files/publication/case-study-bi-level-led-garage-luminaires.pdf

D.6.3.5. Calculation of Deemed Savings

D.6.3.5.1. Energy Savings

$$Annual\ Energy\ Savings\ = \frac{\left(CL_{High} \times 8{,}760\right) - \ (CL_{Low} \times \%_{Low} \times 8{,}760)}{1{,}000}$$

$$Peak\ Demand\ Reduction\ = \frac{CL_{High} - CL_{Low} \times \%_{Low}}{1{,}000}$$

Where:

CL_{High} = Connected load at full power (watts)

CL_{Low} = Connected load at low power or "dimmed" mode (fixture-dependent, ≤70% of full power) (watts)

$8{,}760$ = Annual hours of continuous operation

$\%_{Low}$ = Percent time in lower power or "dimmed" mode (51%)

D.6.3.6. Incremental Cost

The incremental cost is $107.75.[619]

D.6.3.7. Future Studies

Given sufficient participation, the TPE recommends a metering study be conducted to measure percent time in high/low operating modes, as well as peak CF in New Orleans parking structures. Fixture receipts from projects should be recorded so that should the chapter receive a future update, cost information can be used to supplement the incremental cost estimate.

[619] Due to lack of prior studies, the TPE conducted a brief benchmark study comparing bi-level LED fixtures marketed as parking garage fixtures with comparable standard or 'always-on' fixtures.

D.6.4. LED Refrigerated Case Lighting

D.6.4.1. Measure Description

This measure relates to the installation of LED lamps with and without motion sensors in vertical display refrigerators, coolers, and freezers replacing T8 or T12 linear fluorescent lamp technology. LED lamps should be systems intended for this application. LED lamps not only provide the same light output with lower connected wattages, but also produce less waste heat which decreases the cooling load on the refrigeration system and energy needed by the refrigerator compressor. Additional savings can be achieved from the installation of a motion sensor which automatically dims the lighting system when the space is unoccupied. Retrofit projects must completely remove the existing fluorescent fixture end connectors and ballasts to qualify, though wiring may be reused. Eligible fixtures include new, replacement, and retrofit. Savings and assumptions are based on a per door basis.

D.6.4.2. Baseline and Efficiency Standards

The baseline equipment is assumed to be T8 or T12 linear fluorescent lamps without occupancy sensors.

D.6.4.3. Estimated Useful Life (EUL)

The expected measure life is assumed to be 8 years.[620]

D.6.4.4. Calculation of Deemed Savings

D.6.4.4.1. Energy Savings

$$kWh\ Savings\ = \frac{Watts_{base} - \ Watts_{efficient} \times N_{doors} \times Hours \times \ ESF\ \times IEF}{1,000}$$

Where:

$Watts_{base}$ = Connected wattage of baseline fixtures for each door

$Watts_{efficient}$ = Connected wattage of efficient fixtures for each door

N_{doors} = Number of doors

$Hours$ = Annual operating hours (6,205)[1]

ESF = Energy Savings Factor (No occupancy sensors = 1.00, Occupancy sensors = 1.43[621])

[620] Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes annual operating hours of 6,205. <http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf>. The lifetime of the motion sensors is assumed to be equal to the lifetime of the LED lighting.

[621] D. Bisbee, Sacramento Municipal Utilities District, "Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems", July 2008.

IEF = Interactive Effects Factor. Waste heat factor for energy to account for cooling savings from efficient lighting (1.25)

- ***Demand Reduction***

$$kW\ Reduction\ = \frac{Watts_{base} -\ Watts_{efficient} \times N_{doors} \times CF \times\ ESF\ \times IEF}{1{,}000}$$

Where:

$Watts_{base}$ = Connected wattage of baseline fixtures for each door

$Watts_{efficient}$ = Connected wattage of efficient fixtures for each door

N_{doors} = Number of doors

ESF = Energy Savings Factor (No occupancy sensors = 1.00, Occupancy sensors = 1.43[622])

CF = peak coincidence factor (0.99)[623]

IEF = Interactive Effects Factor. Waste heat factor for energy to account for cooling savings from efficient lighting (1.25)

D.6.4.5. Incremental Cost

The incremental capital cost for lighting fixtures is $250 per door (retrofit), and $150 (time of sale, new construction)[624].

If a motion sensor is installed, add an additional cost of $130 per 25ft of case[625].

622 D. Bisbee, Sacramento Municipal Utilities District, "Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems", July 2008.

623 Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. https://www.puc.pa.gov/pcdocs/1340978.pdf.

624 Based on a review of TRM incremental cost assumptions from Oregon and Vermont, supplemented with completed project information from New York.

625 "LED Case Lighting With and Without Motion Sensors" presentation, Michele Friedrich, PECI, January 2010

D.6.5. Light Emitting Diode (LED) Traffic Signals

D.6.5.1. Measure Description

This measure involves the installation of LED traffic signals, typically available in red, yellow, green, and pedestrian format, at a traffic light serving any intersection in retrofit applications. New construction applications are not eligible for this measure, as incandescent traffic signals are not compliant with the current federal standard[626], effective January 1, 2006.

D.6.5.2. Baseline and Efficiency Standards

For all retrofit projects, the baseline is a standard incandescent fixture.

Due to the increased federal standard for traffic signals, the ENERGY STAR® LED Traffic Signal specification was suspended effective May 1, 2007.[627] ENERGY STAR® chose to suspend the specification rather than revise it due to minimal additional savings that would result from a revised specification. Because the ENERGY STAR® specification no longer exists, the efficiency standard is considered to be an equivalent LED fixture for the same application. The equivalent LED fixture must be compliant with the federal standard. There is no current federal standard for yellow "ball" or "arrow" fixtures.

Table D-148: Federal Standard Maximum Nominal Wattages[628], Wattages[629], and Deemed savings

Measure	Nominal Wattage	Maximum Wattage
12" Red Ball	17	11
12" Green Ball	15	15
8" Red Ball	13	8
8" Green Ball	12	12
12" Red Arrow	12	9
8" Green Arrow	11	11
Combination Walking Man/Hand	16	13
Walking Man	12	9
Orange Hand	16	13

[626] Current federal standards for traffic and pedestrian signals can be found at the DOE website at: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/32.

[627] Memorandums related to this decision can be found on the ENERGY STAR® website at: https://www.energystar.gov/index.cfm?c=archives.traffic_signal_spec.

[628] Nominal wattage is defined as power consumed by the module when it is operated within a chamber at a temperature of 25 °C after the signal has been operated for 60 minutes.

[629] Maximum wattage is the wattage at which power consumed by the module after being operated for 60 minutes while mounted in a temperature testing chamber so that the lensed portion of the module is outside the chamber, all portions of the module behind the lens are within the chamber at a temperature of 74 °C, and the air temperature in front of the lens is maintained at a minimum of 49 °C.

Typical incandescent and LED traffic signal fixture wattages can be found in the following table. These fixture wattages should be used in the absence of project specific fixture wattages.

Table D-149: Incandescent/LED Traffic Signal Fixture Wattages

Measure	Incandescent. Wattage[630]	LED Wattage[631]	kWh Savings	kW Savings
Replace 12" Red Incandescent Ball with 12" Red LED Ball	149	9	664.44	0.0756
Replace 12" Yellow Incandescent Ball with 12" Yellow LED Ball		17	34.716	0.0040
Replace 12" Green Incandescent Ball with 12" Green LED Ball		11	517.638	0.0593
Replace 8" Red Incandescent Ball with 8" Red LED Ball	86	6	379.68	0.0432
Replace 8" Yellow Incandescent Ball with 8" Yellow LED Ball		12	19.462	0.0022
Replace 8" Green Incandescent Ball with 8" Green LED Ball		6	300.08	0.0344
Replace 12" Red Incandescent Arrow with 12" Red LED Arrow	128	5	955.833	0.1095
Replace 12" Yellow Incandescent Arrow with 12" Yellow LED Arrow		8	31.56	0.0036
Replace 12" Green Incandescent Arrow with 12" Green LED Arrow		5	89.298	0.0098
Replace Large (16"x18") Incandescent Pedestrian Signal with LED Pedestrian Signal (with Countdown)	149	17	1140.744	0.1307
Replace Small (12"x12") Incandescent Pedestrian Signal with LED Pedestrian Signal (with Countdown)	107	10	838.274	0.0960
Replace Large (16"x18") Incandescent Pedestrian Signal with LED Pedestrian Signal (without Countdown)	116[632]	6	950.62	0.1089
Replace Small (12"x12") Incandescent Pedestrian Signal with LED Pedestrian Signal (without Countdown)	68[633]	5	544.446	0.0624

D.6.5.3. Estimated Useful Life (EUL)

According to the Northwest Power & Conservation Council Regional Technical Forum, the estimated useful life (EUL) is 5 to 6 years, as shown in the following table.

Table D-150: Estimated Useful Life by Measure

Measure	EUL[634]

[630] Northwest Power & Conservation Council: Regional Technical Forum. Commercial LED Traffic Signals measure workbook. http://rtf.nwcouncil.org/measures/measure.asp?id=114&decisionid=37.

[631] Typical practice for estimating fixture wattages is to take an average of the three leading manufacturers: GE, Philips, and Sylvania. Of the three, GE is the only manufacturer providing LED traffic signals. Other manufacturers excluded from averages. http://www.gelightingsolutions.com/products--solutions/transportation-led-lighting/traffic-signals.

[632] Average high wattage A19, A21, and A23 incandescent fixture from Philips and Sylvania.

[633] Ibid.

[634] Northwest Power & Conservation Council: Regional Technical Forum. Commercial LED Traffic Signals measure workbook. http://rtf.nwcouncil.org/measures/measure.asp?id=114&decisionid=37. EUL is determined by LED

	(Years)
Replace 12" Red Incandescent Ball with 12" Red LED Ball	6
Replace 12" Yellow Incandescent Ball with 12" Yellow LED Ball	
Replace 12" Green Incandescent Ball with 12" Green LED Ball	
Replace 8" Red Incandescent Ball with 8" Red LED Ball	
Replace 8" Yellow Incandescent Ball with 8" Yellow LED Ball	
Replace 8" Green Incandescent Ball with 8" Green LED Ball	
Replace 12" Red Incandescent Arrow with 12" Red LED Arrow	
Replace 12" Yellow Incandescent Arrow with 12" Yellow LED Arrow	
Replace 12" Green Incandescent Arrow with 12" Green LED Arrow	
Replace Large (16"x18") Incandescent Pedestrian Signal with LED Pedestrian Signal	5
Replace Small (12"x12") Incandescent Pedestrian Signal with LED Pedestrian Signal	

Traffic Signal replacement schedule, which is set to precede earliest burnout. All fixtures will be replaced at the same time to minimize maintenance interruptions.

D.7. Other Measures

D.7.1. Compressed Air Leak Repair

D.7.1.1. Measure Description

This measure consists of identifying and repairing air leaks in compressed air systems. A compressed air system is used in a commercial or industrial system for pneumatic controls of processes that require compressed air such as air dryers and cleaners. The air compressor is programed to maintain a set air pressure in the system during operating hours and air leaks in the system cause the pressure to drop requiring the system to cycle on or operate at a higher load to maintain the pressure causing the system efficiency to decrease. Air leaks are generally located at hose connections, valves, filters, condensate traps, and end use equipment. The most common method to repair a leak in the compressed air system is by tightening connections, replacing worn-out equipment, replacing cracked gaskets, and isolating unused equipment. This measure can only be applied to a compressed air leak repair cost that includes leak detection and repair.

D.7.1.2. Baseline & Efficiency Standard

The savings values for compressed air leak repair are applicable for existing operational compressed air systems. New construction does not qualify for this measure since it is expected to have no air leaks in the system when newly constructed.

D.7.1.3. Estimated Useful Life (EUL)

The effective useful life (EUL) for this measure is 3 years[635].

D.7.1.4. Deemed Savings Values

Due to the large variability in potential energy savings, the TPE has opted to not include deemed savings per leak repair. Such a value would require too many assumptions and the calculated savings has a large range depending on the system pressure, operating hours, and most importantly the leakage rate.

D.7.1.5. Calculation of Deemed Savings

Annual electric kWh and peak kW savings can be calculated using the following equations and

Table D-115 summarizes the needed variables:

$$\Delta kWh = CFM \times kW_{cfm} \times AOH$$

$$CFM = TCFM \times \left(Leak\%_{pre} - Leak\%_{post}\right)$$

$$\Delta kW = CFM \times kW_{cfm}$$

635 http://ilsagfiles.org/SAG_files/Evaluation_Documents/Draft%20Reports%20for%20Comment/ComEd_Drafts_EPY10/ComEd_EUL_CY2019_CompAir_Evaluation_Research_Plan_Draft_2019-06-07.pdf

Table D-151: Variables for the Deemed Savings Algorithm

Parameter	**Description**	**Value**
CFM	Average leak flow rate, cubic feet per minute	Based on Table D-152
kW_{cfm}	Average compressed air system efficiency, kW per CFM	0.107 default, Table D-153
AOH	Annual hours of operation, hours per year	5702 default, Table D-154
TCFM	Total system flow rate, cubic feet per minutes	Site measured
$Leak\%_{pre}$	Baseline system leakage percentage	25% default
$Leak\%_{post}$	Repaired system leakage percentage	10% default

Table D-152: Estimated Leakage Rate[636]

Gauge Pressure Before Leak	**Diameter of Orifice**				
	1/64”	**1/32”**	**1/16”**	**1/8”**	**1/4"**
50	0.229	0.916	3.66	14.7	58.6
60	0.264	1.06	4.23	16.9	67.6
70	0.3	1.2	4.79	19.2	76.7
80	0.335	1.34	5.36	21.4	85.7
90	0.37	1.48	5.92	23.7	94.8
100	0.406	1.62	6.49	26	104
150	0.582	2.37	9.45	37.5	150
200	0.761	3.1	12.35	49	196
300	0.995	4.88	18.08	71.8	287

Table D-153: Air Compressor Efficiency by Control Type[637]

Control Type	**Compressor Efficiency**	**Weighted Average Percentage**
Reciprocating - On/off control	0.184	0%
Reciprocating - Load/Unload	0.136	40%
Screw - Load/Unload	0.152	0%
Screw - Inlet Modulation	0.055	0%
Screw - Inlet Modulation w/ Unloading	0.055	40%
Screw - Variable Displacement	0.153	20%
Screw - VSD	0.178	0%
Unknown / Weighted Average	0.107	

[636] UE Systems Inc. Compressed Air Ultrasonic Leak Detection Guide

[637] Illinois Technical Reference Manual Version 3.0 Section 4.7.1 VSD Air Compressor

Table D-154: Annual Operating Hours[638]

Building Type	Hours/Days	EFLH	Average Weight
Single shift	8/5	1,976	16%
2-shift	16/5	3,952	23%
3-shift	24/5	5,928	25%
4-shift	24/7	8,320	36%
Unknown / Weighted average		5,702.32	

D.7.1.6. Incremental Cost

Actual program costs should be used. Deemed costs may be applied once program-average cost estimates have been developed (minimum of 20 projects).

[638] Illinois Technical Reference Manual Version 3.0 Section 4.7.1 VSD Air Compressor

D.7.2. Cool Roofs

D.7.2.1. Measure Description

This measure consists of replacing at least 75 percent of the roof area with a cool roof. A cool roof is a material of low specific heat and high reflectivity. The primary action of structure heat rejection is the reflection of solar heat back into the atmosphere, but additional heat rejection is realized by the low specific heat of the material quickly radiating any accumulated heat within it out into the atmosphere. A cool roof is defined by ASHRAE 90.1 as a roof having a minimum solar reflectivity of 0.55 and a minimum thermal emittance of 0.75. ASHRAE 90.1-2007 provides an alternative approach allowing products with a minimum Solar Reflective Index (SRI) of 64. The Cool Roof Rating Council (www.coolroofs.org) maintains an SRI database.

D.7.2.2. Baseline & Efficiency Standard

The savings values for cool roof replacement repairs are applicable for all existing baseline roofs. The baseline efficiency is estimated with a solar reflectance of 0.23 and thermal emittance of 0.90.[639]

D.7.2.3. Estimated Useful Life (EUL)

The effective useful life (EUL) for this measure is 15 years.[640]

D.7.2.4. Deemed Savings Values

Deemed savings values for annual electric energy use (kWh), peak demand (kW) are provided in the following tables, arranged by HVAC configuration.

Table D-155: DX Cooling with Gas Heating

Building Type		***kWh/sq. ft.^{2}***	***kW/1000 ft.^{2}.***
Education	Primary School	0.0838	0.0065
	Secondary School	0.0753	0.0047
	Community College	0.1320	0.0372
	University	0.1438	0.0398
Office	Large	0.2346	0.0622
	Small	0.0983	0.0294
Retail	3-Story Large	0.1605	0.0428
	Single-Story Large	0.2685	0.0756
	Small - Retail	0.1125	0.0293
Restaurant	Fast Food	0.1099	0.0299

639 Average reflectance properties of roofing material as obtained from the publication *Laboratory Testing and Reflectance Properties of Roofing Material* by Florida Solar Energy Center and the predominant roof material used in west south central region for non-small commercial buildings as obtained from CBECS 2003, Table B4

640 DEER 2014 EUL tables

Table D-156: DX Cooling with Electric Resistance Heating

Building Type		***kWh/sq. ft.^{2}***	***kW/1000 ft.^{2}***
Education	Primary School	0.0544	0.0065
	Secondary School	0.0558	0.0047
	Community College	0.1164	0.0348
	University	0.1339	0.0398
Office	Large	0.2168	0.0622
	Small	0.0785	0.0295
Retail	3-Story Large	0.1488	0.0428
	Single-Story Large	0.2381	0.0750
	Small - Retail	0.0808	0.0295
Restaurant	Fast Food	0.0743	0.0298

Table D-157: Heat Pump

Building Type		***kWh/sq. ft.^{2}***	***kW/1000 ft.^{2}***
Education	Primary School	0.0718	0.0065
	Secondary School	0.0684	0.0047
	Community College	0.1312	0.0372
	University	0.1431	0.0398
Office	Large	0.2346	0.0622
	Small	0.0785	0.0295
Retail	3-Story Large	0.1605	0.0428
	Single-Story Large	0.2566	0.0750
	Small - Retail	0.0978	0.0295
Restaurant	Fast Food	0.0963	0.0298

Table D-158: Chiller Loop Cooling W/ HW Boiler Loop Heating

Building Type		***kWh/ ft.^{2}***	***kW/1000 ft.^{2}***
Education	Secondary School	0.1126	0.0111
	Community College	0.0890	0.0228
	University	0.1088	0.0331
Office	Large	0.1780	0.0637
Retail	3-Story Large	0.1059	0.0301

D.7.2.5. Calculation of Deemed Savings

eQUEST was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since Cool Roof savings are sensitive to weather, available TMY3 weather data specific to New Orleans was used for the analysis. The prototype building characteristics used in the building model are outlined in Appendix A.

D.7.2.6. Incremental Cost

Actual measure cost should be used where available. If not available, the incremental cost of a installing a cool roof is $8.45 per square foot. [641]

[641] 2005 Database for Energy-Efficiency Resources (DEER), version 2005.2.01, "Technology and Measure Cost Data", California Public Utilities Commission, October 26, 2005

D.7.3. Air Curtains

D.7.3.1. Measure Description

This measure applies to buildings with exterior entryways that utilize overhead doors. All other air curtain applications, such as through sliding door entryways or conventional foot-traffic entryways, require custom analysis as air curtain designs must often accommodate other factors that may change their effectiveness.

The use of overhead doors within exterior entryways during the heating season leads to the exfiltration of warm air from the upper portion of the door opening and the infiltration of colder air from the lower portion of the door opening. This results in increase heating energy use to compensate for heat losses every time a door is opened. By reducing heat losses, air curtains can also enhance the physical comfort of employees or customers near the entryway as there will be reduced temperature fluctuations when the door is opened and closed. In addition, in some cases excess heating capacity may be installed in buildings to meet this larger heating load. The addition of air curtains to exterior entryways that currently utilize overhead doors will result in energy savings and enhanced personal comfort, and also possibly in reduced equipment sizing and corresponding costs.

The primary markets for this measure are commercial and industrial facilities with overhead doors in exterior entryways, including but not limited to the following building types: retail, manufacturing, and warehouse (non-refrigerated).

Limitations:

- For use in conditioned spaces with an overhead door in an exterior entryway. This measure does include other door types such doorways to commercial spaces such as retail.
- This measure should only be applied to spaces in which the overhead door separates a conditioned space and an unconditioned space.
- Installation must follow manufacturer recommendations to attain proper air velocity, discharge angle down to the floor level, and unit position.
- Certain heating systems may not be a good fit for air curtains, such as locations with undersized heating capacity. In these cases, the installation of an air curtain may not effectively reduce heating system cycling given the inappropriately sized heating capacity.
- Buildings with slightly positive to slightly negative (~5 Pa to -10 Pa). For all other scenarios, custom analysis is recommended.
- Measure assumes that wind speeds at near ground level are less than or equal to 12 mph for 90% of the heating or cooling season. For areas with more extreme weather, custom analysis is necessary.

D.7.3.2. Baseline and Efficiency Standards

No air curtain or other currently installed means to effectively reduce heat loss and air mixing during door openings, such as a vestibule or strip curtain.

Overhead air curtains designed for commercial and industrial applications that have been tested and certified in accordance with ANSI/AMCA 220 and installed following manufacturer guidelines. Measure is for standard models without added heating.

D.7.3.3. Estimated Useful Life (EUL)

The expected measure life is assumed to be 15 years.[642]

D.7.3.4. Deemed Savings Values

Door Size	***kWh/ft²***	***kW/ft²***
Egress	293	0.046
8'w x 8'h	309	0.048
10'w x 10'h	344	0.053
10'w x 12'h	365	0.055
12'w x 14'h	392	0.059
16'w x 16'h	417	0.062

D.7.3.5. Calculation of Deemed Savings

The following methodology is highly complex and requires significant data collection. It is hoped that simplifying steps can be made in future iterations based on metering and evaluation of installations. The data collected through implementing the measure in the way currently drafted will aid in simplifying efforts at a future date.

D.7.3.5.1. Energy Savings

$$kWh_{cooling} = \left[\frac{(Q_{tbc} - Q_{tac})}{EER} - (HP * 0.7457)\right] * t_{open} * CBP$$

$$kWh_{HP\ heating} = \left[\frac{(Q_{tbc} - Q_{tac})}{HSPF} - (HP * 0.7457)\right] * t_{open} * HBP$$

$$kWh_{Gas\ Heating} = -(HP * 0.7457) * t_{open} * HDD$$

Where:

Q_{tbc} = rate of total heat transfer through the open entryway, before air curtain (kBtu/hr)

Q_{tac} = rate of total heat transfer through the open entryway, after air curtain (kBtu/hr)

(see calculation in 'Heat Transfer Through Open Entryway with/without Air Curtain' sections below)

642 Navigant Consulting Inc, Measures and Assumptions for Demand Side Management (DSM) Planning: Appendix C: Substantiation Sheets, "Air Curtains – Single Door," Ontario Energy Board, (April 2009): C-137. 2014 Database for Energy-Efficient Resources, EUL/RUL (Effective/Remaining Useful Life) Values, February 4, 2014.

EER = energy efficiency ratio of the cooling equipment (kBtu/kWh)

HP = Input power for air curtain (hp)

Table D-159: Fan Horsepower

Door Size	Fan HP
8'w x 8'h	1
10'w x 10'h	1.5
10'w x 12'h	4
12'w x 14'h	6
16'w x 16'h	12

0.7457 = unit conversion factor, brake horsepower to electric power (kW/HP)

t_{open} = average hours per day the door is open (hr/day)

CB = Cooling Balance Point, total days in year above balance point temperature 65 °F (day) = 239

HSPF = Heating System Performance Factor of heat pump equipment

HB = Heating Balance Point, total days in year above balance point temperature 65 °F (day) = 126

Heat Transfer Through Open Entryway without Air Curtain (Cooling Season)

$$Q_{tbc} = 4.5 * CFM_{tot} * \frac{h_{oc} - h_{ic}}{1{,}000\,\frac{Btu}{kBtu}}$$

Where:

4.5 = unit conversion factor with density of air: $60\,\frac{min}{hr} \,*\, 0.075\,\frac{lbm}{ft^3}, \left(\frac{lb*min}{ft*hr}\right)$

CFM_{tot} = Total air flow through entryway (cfm), see calculation below

h_{oc} = average enthalpy of outside air during the cooling season (Btu/lb). See table below.[643]

Table D-160: Average Enthalpy of Outside Air

Location	67 °F	72 °F	77 °F
New Orleans	35.7	36.6	37.7

h_{ic} = average enthalpy of indoor air, cooling season (Btu/lb). See the below table to determine the approximate indoor air enthalpy associated with an indoor temperature setpoint in indoor relative humidity. An estimate 26.6 Btu/lb associated with the 72 °F and 50% indoor relative humidity case can be used as an approximation if no other data is available. For other indoor temperature setpoints and RH, enthalpies may be interpolated.

[643] Enthalpy values were calculated based on TMY3 dry bulb temperatures.

Table D-161: Average Humidity

Humidity (%)	**67 °F**	**72 °F**	**77 °F**
60	25.5	28.5	31.8
50	23.9	26.6	29.5
40	22.3	24.7	27.3

The total airflow through the entryway, CFM_{tot}, includes both infiltration due to wind as well as thermal forces, as follows:

$$CFM_{tot} = \sqrt{(CFM_w)^2 + (CFM_t^2)}$$

Where:

CFM_w = Infiltration due to the wind (cfm)

CFM_t = Infiltration due to thermal forces (cfm)

The infiltration due to the wind is calculated as follows:

$$CFM_w = (v_{wc} * C_{wc}) * C_v * A_d * \left(88 \frac{fpm}{mph}\right)$$

Where:

v_{wc} = average wind speed during the cooling season (mph) = 3.48[644]

C_{wc} = wind speed correction factor due to wind direction in cooling season, (%). Because wind direction is not constant, a wind speed correction factor is used to adjust for the amount of time during the cooling season prevailing winds can be expected to impact the entryway. =0.2395[645]

C_v = effectiveness of openings = 0.3, assumes diagonal wind[646]

A_d = area of the doorway (ft^2) = user defined

The infiltration due to thermal forces is calculated as follows:

$$CFM_t = A_d * C_{dc} * \left(60 \frac{sec}{min}\right) * \sqrt{2 * g * \frac{H}{2} * \frac{T_{oc} - T_{ic}}{459.7 + T_{oc}}}$$

Where:

C_{dc} = the discharge coefficient during the cooling season483

$$C_{dc} = 0.4 + 0.0025 * |T_{ic} - T_{oc}|$$

g = acceleration due to gravity = 32.2 ft/sec2

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644 Average wind speeds were calculated based on the TMY3 wind speed data.

645 Mean of directional correction factors, Illinois TRM

646 ASHRAE, "Airflow Around Buildings," in 2013 ASHRAE Handbook – Fundamentals (2013): p 24.3

H = the height of the entryway (ft)

T_{ic} = Average indoor air temperature during cooling season = assumed HVAC setpoint of 72°F

T_{oc} = Average outdoor temp during cooling season (°F) = the average outdoor temperature is dependent on the CDD period and zone. See table below.[647]

Table D-162: Average Outdoor Air During Cooling Season

	T_{OC}				
Climate Zone	***62 °F***	***67 °F***	***72 °F***	***77 °F***	***82 °F***
New Orleans	75.8	78.2	80.0	82.8	85.6

459.7 = conversion factor from °F to °R = calculation requires absolute temperature for values not calculated as a difference of temperatures.

Heat Transfer Through Open Entryway with Air Curtain (Cooling Season)

$$Q_{tac} = Q_{tbc} * (1 - E)$$

Where:

E = the effectiveness of the air curtain (%) = 0.60485

D.7.3.5.2. Demand Savings

$$\Delta kW = (\Delta kWh_{cooling} / (CDD * 24)) * CF$$

Where:

CF = Coincidence Factor for Commercial cooling = 91.30[648]

D.7.3.6. Incremental Cost

The incremental capital cost for overhead air curtains for exterior entryways are as follows, with an added average installation cost approximately equal to the capital cost.[649]

Table D-163: Incremental Cost by Door Size

Door Size	***Capital Cost***
8’w x 8’h	$3,600
10’w x 10’h	$4,500
10’w x 12’h	$5,400
12’w x 14’h	$8,000
16’w x 16’h	$13,300

[647] Average temperatures were calculated based on TMY3 wet bulb temperatures.

[648] IL TRM V5.0 Vol.2 Sec. 4.4.33 , Page 307

[649] IL TRM V5.0 Vol.2 Sec. 4.4.33 , Page 301

D.7.4. Window Film

D.7.4.1. Measure Description

This measure consists of the addition of solar film to the inside of glazing on the east and west windows of small commercial buildings less than 15,000 gross square feet (any direction except 45 degrees of true north). This measure is based on square footage of qualifying windows.

D.7.4.2. Baseline and Efficiency Standards

This measure is applicable to existing commercial buildings with clear single- or double-pane glazing with a solar heat gain factor (SHGC) greater than 0.66. Existing Low E windows, windows with existing solar films or solar screens are not eligible for this measure.

In order to qualify for deemed savings, solar film should be applied to glass facing east or west. The SHGC of the films must be less than 0.50.

The windows must not be shaded by existing awnings, exterior curtains or blinds or any other shading device. They must be installed in a space conditioned by refrigerated air conditioning (central, window or wall unit).

The windows must meet all applicable codes and standards, including:

- ASTM-408: Standard Method for Total Normal Emittance by inspection meter.
- ASTM E-308: Standard Recommended Practice for Spectro-Photometry and Description of Color in CIE1931 (this is an indicator of luminous reflection and visibility).
- ASTM-E903: Standard Methods of Test for Solar Absorbance, Reflectance and Transmittance using an integrated sphere.
- ASTM G-90: Standard Practice for Performing Accelerated Outdoor Weatherizing for Non-Metallic Materials Using Concentrated Natural Light.
- ASTM G26: Xenon arc weathering to accelerate natural aging.
- ASTM E-84: Flammability for commercial and residential structures.

D.7.4.3. Estimated Useful Life (EUL)

The average lifetime of this measure is 10 years, according to DEER 2008.

D.7.4.4. Deemed Savings Values

Deemed savings values for annual electric energy use (kWh) and peak demand (kW) are provided in the tables on the following pages.

Table D-164: Window Film Deemed Savings by Direction and Heating Type

Direction of Window Film	DX Coils with Furnace		Heat Pump		Electric Resistance	
	Energy Savings	Peak Demand Savings	Energy Savings	Peak Demand Savings	Energy Savings	Peak Demand Savings
	kWh / sq. ft.	kW / 1000 sq. ft.	kWh / sq. ft.	kW / 1000 sq. ft.	kWh / sq. ft.	kW / 1000 sq. ft.
East	10.24	2.54	3.08	2.59	5.04	2.59
West	12.32	5.29	6.13	5.43	7.76	5.43

D.7.4.5. Calculation of Deemed Savings

Deemed savings are applicable to commercial buildings and were calculated using two representative buildings: a strip mall and a small office building. Estimated savings for the east and west window surfaces were based on a small office building with equal window surfaces on all four sides and for strip malls having glazing on one side. The deemed savings values presented herein represent the average savings per square foot of glazing for windows in each weather zone facing east and west.

D.7.4.6. Incremental Cost

The incremental cost is $2-2.50 per square foot[650].

[650] https://www.energystar.gov/ia/new_homes/comments/Background2.pdf

D.7.5. Plug Load Occupancy Sensors

D.7.5.1. Measure Description

Plug load occupancy sensors are devices that control low wattage devices (<150 watts) using an occupancy sensor. Common applications are computer monitors, desk lamps, printers, and other desktop equipment. Three wattage tiers were analyzed based on available products in the market: 25W, 50W, and 150W.

D.7.5.2. Baseline and Efficiency Standards

Table D-165: Plug Load Without Occupancy Sensors– Baseline Data

Size (watts)	Annual Energy Consumption[651] (kWh/ unit)	Annual Operating Hours	Demand (kW/unit)
25	110	4,400	0.025
50	220	4,400	0.05
150	555	3,700	0.15

Table D-166 contains the annual energy consumption and demand for plug load occupancy sensors.

Table D-166: Plug Load Occupancy Sensors – Minimum Requirements

Size (watts)	Annual Energy Consumption[652] (kWh/ unit)	Annual Operating Hours	Demand[1] (kW/ unit)
25	45	1452	0.025
50	91	1452	0.050
150	234	1250	0.150

D.7.5.3. Estimated Useful Life (EUL)

According to DEER 2014, the estimated useful life (EUL) is eight years.

[651] Arkansas TRM

[652] Ibid.

D.7.5.4. Deemed Savings Values

Deemed measure costs and savings for various sized plug load occupancy sensors are provided in Table *D-167*.

Table D-167: Plug Load Occupancy Sensors – Deemed Savings Values

Measure	***Demand Savings[1] (kW/ unit)***	***Annual Energy Savings[1] (kWh/ unit)***
25W sensor	0.000	65
50W sensor	0.000	129
150W sensor	0.000	321

D.7.5.5. Calculation of Deemed Savings

Four resources contained information on plug load occupancy sensors. The energy savings and amount of equipment controlled per sensor varied widely. The values for energy and demand savings are given in Table *D-168*.

Table D-168: Review of Plug Load Occupancy Sensor Measure Information

Available Resource	***Type***	***Size***	***Annual Energy Saving (kWh/unit)***	***Demand Savings (kW/unit)***
PG&E 2003	Plug load occupancy sensor	150	300	0.124
Quantec 2005	Power strip occupancy sensor	N/A	27	0.012
DEER 2005	Plug load occupancy sensor	50	143	0.051
KEMA 2010	Plug load occupancy sensor	50	221	0.025
NPCC 2005	Cubicle occupancy sensor	25	55	0.025
PacifiCorp 2009	Unitary savings included in comprehensive potential study		196	0.00

D.7.5.6. Incremental Cost

The incremental cost is $70.[653]

D.7.5.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. If this measure is added to Energy Smart programs, the evaluation should include a field assessment to inventory the plug loads actually controlled.

[653] Ohio TRM.

D.7.6. Advanced Power Strips

D.7.6.1. Measure Description

This measure involves the installation of a multi-plug Advanced Power Strip (APS) that has the ability to automatically disconnect specific loads depending on the power draw of a specified or “master” load. A load sensor in the strip disconnects power from the control outlets when the master power draw is below a certain threshold. The energy savings calculated for this measure are derived by estimating the number of hours that devices in typical office workstations are in “off” or “standby” mode and the number of watts consumed by each device in each mode. When the master device (i.e. computer) is turned off, power supply is cut to other related equipment (i.e. monitors, printers, speakers, etc.), eliminating these loads.

Commercial deemed savings were developed based on reported plug load electricity consumption. The assumed mix of peripheral electronics, and related data, are presented in the following table.

Table *D-169* shows the assumed number of hours each device is typically in “off” mode. Given the assumption that the master device, a desktop computer, will only be in off mode during non-work hours, watts consumed by devices in standby-mode are not counted toward energy savings for a commercial APS. Workday and weekend day watts consumed in off mode are a function of hours multiplied by estimated watt consumption.

There are two deemed savings paths available: Savings can be estimated as follows: 1) per APS for an average complete system or 2) by individual peripheral device.

Table D-169: Peripheral Watt Consumption Breakdown

Peripheral Device	Workday Daily Off Hours[654]	Weekend Daily Off Hours	Off Power (W)[655,656]	Workday (W-hr) [A]	Weekend (W-hr) [B]
Coffee Maker	16	24	1.14	18.24	27.36
Computer: Desktop	16	24	3.3	52.80	79.20
Computer: Laptop	16	24	4.4	70.40	105.60
Computer Monitor: CRT	16	24	1.5	24.00	36.00
Computer Monitor: LCD	16	24	1.1	17.60	26.40
Computer Speakers	16	24	2.3	36.80	55.20
Copier	16	24	1.5	24.00	36.00
External Hard Drive	16	24	3.0	48.00	72.00
Fax Machine: Inkjet	16	24	5.3	84.80	127.20
Fax Machine: Laser	16	24	2.2	35.20	52.80
Media Player: Blu-Ray	16	24	0.1	1.60	2.40
Media Player: DVD	16	24	2.0	32.00	48.00
Media Player: DVD-R	16	24	3.0	48.00	72.00
Media Player: DVD/VCR	16	24	4.0	64.00	96.00
Media Player: VCR	16	24	3.0	48.00	72.00
Microwave	16	24	3.08	49.28	73.92
Modem: Cable	0	24	3.8	0.00	91.20
Modem: DSL	0	24	1.4	0.00	33.60
Multi-Function Printer: Inkjet	16	24	5.26	84.16	126.24
Multi-Function Printer: Laser	16	24	3.12	49.92	74.88
Phone with Voicemail	16	24	2.92	46.72	70.08
Printer: Inkjet	16	24	1.3	20.80	31.20
Printer: Laser	16	24	3.3	52.80	79.20
Router	16	24	1.7	27.20	40.80
Scanner	16	24	2.1	33.60	50.40
Television: CRT	16	24	1.6	25.60	38.40
Television: LCD	16	24	0.5	8.00	12.00
Television: Plasma	16	24	0.6	9.60	14.40
Television: Projection	16	24	7.0	112.00	168.00

[654] Commercial hours of operation based on typical 8-hour workday schedule.

[655] New York State Energy Research and Development Authority (NYSERDA), “Advanced Power Strip Research Report”. August 2011.

[656] Standby Power Summary Table, Lawrence Berkeley National Laboratory. http://standby.lbl.gov/summary-table.html.

D.7.6.2. Baseline and Efficiency Standards

The baseline case is the absence of an APS, where peripherals are plugged into a traditional surge protector or wall outlet. The baseline assumes a typical mix of office equipment, shown in

Table D-169.

D.7.6.3. Estimated Useful Life (EUL)

The estimated useful life (EUL) is 10 years according to the New York State Energy Research and Development Authority (NYSERDA) Advanced Power Strip Research Report from August 2011.[657]

D.7.6.4. Calculation of Deemed Savings

D.7.6.4.1. Energy Savings

Energy savings for a 7-plug APS in use in a commercial setting are calculated using the following algorithm, where kWh saved are calculated and summed for all peripheral devices:

$$\Delta kWh = \frac{\sum(Workdays * \ A_i) + \sum\left((365 - Workdays) * \ B_i\right)}{1{,}000}$$

Where:

$Workdays$ = Average number of workdays per year[658] = 240 days

A = Watt-hours/day consumed in the “off” mode per workday

B = Watt-hours/day consumed in the “off” mode per weekend day

$1{,}000$ = Constant to convert watts to kilowatts

D.7.6.4.2. Demand Savings

No demand savings are awarded for this measure due to the assumption that typical office equipment will be operating throughout the workday.

D.7.6.5. Deemed Savings Values

Energy savings from an APS in an office setting are estimated to be 71.4 kWh using the above equation and assuming six unique peripheral devices. Energy savings per peripheral device are also available in the following table.

[657] New York State Energy Research and Development Authority (NYSERDA): Advanced Power Strip Research Report, p. 30. August 2011.

[658] Assuming 50 working weeks, deducting 2 weeks for federal holidays and another 2 weeks for vacation; 48 weeks x 5 days/week = 240 days

Table D-170: Advanced Power Strips – Deemed Savings Values

Peripheral Device	***kWh Savings***
Coffee Maker	7.8
Computer: Desktop	22.6
Computer: Laptop	30.1
Computer Monitor: CRT	10.3
Computer Monitor: LCD	7.5
Computer Speakers	15.7
Copier	10.3
External Hard Drive	20.5
Fax Machine: Inkjet	36.3
Fax Machine: Laser	15.0
Media Player: Blu-Ray	0.7
Media Player: DVD	13.7
Media Player: DVD-R	20.5
Media Player: DVD/VCR	27.4
Media Player: VCR	20.5
Microwave	21.1
Modem: Cable	11.4
Modem: DSL	4.2
Multi-Function Printer: Inkjet	36.0
Multi-Function Printer: Laser	21.3
Phone with Voicemail	20.0
Printer: Inkjet	8.9
Printer: Laser	22.6
Router	11.6
Scanner	14.4
Television: CRT	10.9
Television: LCD	3.4
Television: Plasma	4.1
Television: Projection	47.9
Average APS: Small Business Whole System[659]	**61.2**

[659] Assuming Computer Monitor: LCD, Computer Speakers, Modem: Average, Printer: Average, and Scanner. Computer not included because it is assumed to be the controlling load. This average value is meant to apply to a typical small business application and should not be applied in other applications. For other applications, calculate the savings for each individual equipment type. kWh savings = 7.5 + 15.7 + [(11.4 + 4.2) ÷ 2] + [(8.9 + 22.6) ÷ 2] + 14.4 = 61.2 kWh.

D.7.6.6. Incremental Cost

The incremental cost is $16 for a 5-plut and $26 for a 7-plug strip[660].

D.7.6.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. If this measure is added to Energy Smart programs, the evaluation should include a field assessment to inventory the plug loads actually controlled.

[660] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4

D.7.7. Computer Power Management

D.7.7.1. Measure Description

Computer Power Management (CPM) is the automated control of the power, or "sleep" settings of network desktop and notebook computer equipment. CPM involves using built-in features or add-on software programs to switch off displays and enable computers to enter a low power setting called sleep mode during periods of non-use. This measure applies to both ENERGY STAR® and conventional computer equipment and assumes that the same computer equipment is being used before and after CPM settings are activated. The power draw of a computer is assumed to be roughly equivalent during active and idle periods, so for the purposes of calculating savings, we will combine the terms active and idle as "active/idle" throughout the document.

D.7.7.2. Baseline and Efficiency Standards

The baseline conditions are the estimated number of hours that the computer spends in idle and sleep mode before the power settings are actively managed. The efficient conditions are the estimated number of hours that the computer spends in active/idle and sleep mode after the power settings are actively managed. Operating hours may be estimated from metering, or the default hours provided in the calculation of deemed savings may be used.

D.7.7.3. Calculation of Deemed Savings

Deemed demand and annual savings are based on the ENERGY STAR® Low Carbon IT Savings calculator. The coincidence factor, default equipment wattages in Table D-171, and the active/idle and sleep hours are taken from assumptions in the ENERGY STAR® calculator with all equipment set to enter sleep mode after 15 minutes of inactivity.

$$kWh_{savings} = \frac{W_{active/idle}\left(hours_{active/idle_{pre}} - hours_{active/idle_{post}}\right) + W_{sleep}\left(hours_{sleep_{pre}} - hours_{sleep_{post}}\right)}{1,000}$$

$$kW_{savings} = \frac{(W_{active/idle} - W_{sleep}) * CF}{1,000}$$

Where:

$W_{active/idle}$ = total wattage of the equipment, including computer and monitor, in active/idle mode; see Table D-171.

$Hours_{active\_idle\_pre}$ = annual number of hours the computer is in active/idle mode before computer management software is installed = 6,293

$Hours_{active\_idle\_post}$ = annual number of hours the computer is in active/idle mode after computer management software is installed = 1,173

W_{sleep}= total wattage of the equipment, including computer and monitor, in sleep mode; see Table D-171

$Hours_{sleep\_pre}$= annual number of hours the computer is in sleep mode before computer management software is installed = 0

$Hours_{sleep\_post}$ = annual number of hours the computer is in sleep mode after computer management software is installed = 5,120

CF= Coincidence Factor[661] = 0.25

1,000 = W/kW conversion

Table D-171: Computer Power Management - Equipment Wattages

Equipment	W_{sleep}	$W_{active/idle}$
Conventional LCD Monitor	1	32
Conventional Computer	3	69
Conventional Notebook (including display)	2	21

Table D-172: Computer Power Management - Deemed Savings Values

Equipment	***kWh savings***	***kW savings***
Conventional LCD Monitor	158.72	0.008
Conventional Computer	337.92	0.017
Conventional Notebook (including display)	97.28	0.005

D.7.7.4. Estimated Useful Life (EUL)

The EUL of this measure is based on the useful life of the computer equipment which is being controlled. Computer technology may continue to function long after technological advances have diminished the usefulness of the equipment. The EUL for Computer Power Management is 4 years.[662]

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[661] The coincidence factor is the percentage of time the computer is assumed to be not in use during the hours 3pm to 6pm from the ENERGY STAR® calculator modeling study.

[662] The Regional Technical Forum, Measure workbook for Commercial: Non-Res Network Computer Power Management. http://rtf.nwcouncil.org/measures/measure.asp?id=95. Accessed August 2013.

D.7.7.5. Incremental Cost

The incremental cost is $29 per computer, including labor.[663]

D.7.7.1. Future Studies

At the time of authorship of the New Orleans TRM Version 3.0, this measure was not implemented in Energy Smart programs. If this measure is added to Energy Smart programs, the evaluation should include a field assessment to inventory the plug loads actually controlled.

[663] Work Paper WPSCNROE0003 Revision 1, Power Management Software for Networked Computers. Southern California Edison

E. Appendix A: Inputs

E.1.1. Residential

E.1.1.1. ENERGY STAR© Appliances

Unless otherwise noted, deemed savings values and inputs were derived form and found in the Energy Star calculators: https://www.energystar.gov/products/appliances.

E.1.1.2. Domestic Hot Water

E.1.1.2.1. Ambient Water Main (Tin) and Ambient Air Temperature (Tamb) Calculations based on New Orleans City Climate

Ambient Water Main (Tin) and Outside Air Temperature (Tamb) Calculations based on TMY3 New Orleans climate data

New Orleans	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual Avg*
Month	1	2	3	4	5	6	7	8	9	10	11	12	
Outside Air Temperature (T_{air})	49.9	55.6	64.1	69.4	75.1	80.7	81.6	82.3	77.7	68.2	65.6	54.5	**68.7**
Water Heater Inlet Water Temperature, (T_{in})	66.0	64.2	65.2	68.6	73.6	78.9	83.1	85.2	84.4	81.2	76.3	70.9	**74.8**
offset (district water) =	6.00												
ratio =	0.647												
lag =	34.8												

E.1.1.2.2. Estimated Hot Water Usage (By Tank Size)

The values in the table below are based off Table 136: Estimated Annual Hot Water Use (gal), Arkansas TRM 5.0, page 137.

Tanks Size (gal) of Replaced Water Heater	*40*	*50*	*65*	*80*
El Dorado Estimated Annual Hot Water Use (gal)	17,815	20,245	24,293	29,152

The TPE created a correction factor to compensate for the difference in the average water main temperatures between the two cities.

$$\textbf{Correction Factor} = \frac{\textbf{El Dorado Average Water Main Temperature}}{\textbf{New Orleans Average Water Main Temperature}} = \frac{\textbf{70.1}}{\textbf{74.8}} = \textbf{.937166}$$

The correction factor was applied to existing El Dorado hot water usage estimates resulting on values appropriate for New Orleans:

Tanks Size (gal) of Replaced Water Heater	***40***	***50***	***65***	***80***
New Orleans Estimated Annual Hot Water Use (gal)	16,696	18,973	22,767	27,320

E.1.1.2.3. Estimated Average Ambient Temperatures by Water Heater Installation Location

Average ambient air temperature, New Orleans (TMY3)	68.78
Number of heating degree days, New Orleans (TMY3, base 65)	126
Number of cooling degree days, New Orleans (TMY3, base 65)	239
Ratio of conditioned/unconditioned	1.00549

E.1.1.2.4. Heat Pump Water Heater Adjustment Factor

	Count	***% of year***
Heating Days	126	35%
Cooling Days	239	65%

PA% for conditioned space: 2.784%

	COP-Heating	***COP-Cooling***	***Calculated F Adj***	***Calculated Adj***	***Estimated Adj***
Gas	20	3	1.201	0.856	**0.917**
Heat Pump	2	3	1.046	0.983	**1.201**
Elec.Resistance	0.89	3	0.830	1.238	**1.395**

E.1.1.2.5. Water Heater Jackets Deemed Savings Values

Estimated hot water usage (by tank size) Deemed water heating jacket savings are Table 143: Water Heater Jackets – Electric Heating Deemed Savings Values Arkansas TRM 5.0, page 144.

E.1.1.2.6. Annual Average Daily Isolation

Daily Total Insolation (BTU/ft2/day) (AR TRM 5.0)	1,601
Average solar radiation El Dorado, AR (NREL)	1,407
Average solar radiation New Orleans, LA (NREL)	1,405
Correction factor	1.137
New Orleans Solar radiation x Correction Factor =	**1,598**

E.1.1.2.7. Weather Zone Localization Factor for SEF

Average solar radiation New Orleans, LA (NREL): 4.33 kWh/m2/day = 1,405.254 BTU/ft2/day

Average solar radiation El Dorado, AR (AR TRM 5.0): 1,601 BTU/ft2/day

Latitude correction factor: 1.137

E.1.1.3. Envelope

E.1.1.3.1. Prototype Building Characteristics

Various building energy usage computer models have been used in development of deemed savings included in the TRM according to several factors:

- Building Type and Use. Prototype buildings support deemed savings development for measures to be implemented in the following building types: residential, converted residence (CR), commercial, and small commercial (SC).
- Model Vintage. Original prototypes date back to deemed savings developed in 2007/08 for use in the QuickStart programs. Prototype inputs have been updated for more recent models.
- Measure being modeled. Specific changes to a prototype are introduced to represent the specific measure being implemented in a given building.

In this Appendix, “top level” tables – those tables with the letter A followed only by a number in their table name (e.g. Table A1) provide the general characteristics of a given model prototype. “Supplemental tables” – (e.g. Table A1.a) – provide the specific changes introduced to a given prototype for the modeling of specific measures.

The following table applies to the Attic Knee Wall Insulation, Ceiling Insulation, Wall Insulation, Floor Insulation, Roof Deck Insulation, Air Infiltration, Radiant Barriers, ENERGY STAR® Windows, and Window Film measures. Unique modifications for each specific measure are listed in supplemental Tables A3.a through A3.h. BEopt™ – a residential building modeling platform developed by NREL – was used to estimate energy savings for these measures using the U.S. DOE EnergyPlus simulation engine.

Residential Envelope Measures – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Site/Layout		
Conditioned Floor Area	1,764 ft.^{2}	Average square footage of conditioned (heated) space between one story home and all SFD homes in 2009 RECS microdata for AR/LA/OK.[664]
Orientation	Square building with faces on each cardinal direction	LBNL: Nationally Representative Housing Sample[665]
Number of Stories	Single story with unfinished attic	Preponderance of SFD homes in 2009 RECS microdata are single story
Building Envelope		
Foundation	Slab-on-ground, no edge insulation	Preponderance of SFD homes in 2009 RECS microdata (62%) have slab foundation Also a conservative assumption for base energy usage.
Slab Insulation	None – no perimeter, under-slab, or above-slab insulation	Not part of standard practice, also no requirement for slab insulation in residential code for relevant weather regions except the NW corner of state in IECC Climate Zone 4.
Ceiling Insulation	R-12	Table 25 of BA Home Simulation Protocols suggests R-9 is appropriate for homes closed rafter roofs built with 2 x 6 beams, R-15 for 2 x 10. Suspect 2 x 6 is more likely, but some share of homes will have had ceiling insulation replaced/added. Select R-12 based

[664] 2009 RECS, Available at: http://www.eia.gov/consumption/residential/data/2009/

[665] Simulating a Nationally Representative Housing Sample Using EnergyPlus, Available at: http://www.osti.gov/scitech/servlets/purl/1012239

		on the above information and engineering judgment.[666]
Wall Insulation	R-11	BAHSP, p. 35 – value for homes built 1980-1989
Air Leakage	0.9 ACH	Median ACH for older, low income housing.[667]
Fenestration		
Window Area	15% of wall area	American Housing Survey 2007 and 2008 was used to inform the value for likely participants.
Window U-value (single pane)	1.12	2009 ASHRAE Fundamentals, Ch. 15 Table 4. Value for double-pane, metal frame, fixed, clear glass window.
Window U-value (double pane)	0.65	2009 ASHRAE Fundamentals, Ch. 15 Table 4. Value for double-pane, metal frame, fixed, clear glass window.
Window SHGC	0.79	2009 ASHRAE Fundamentals, Ch. 15 Table 10. Value for double-pane, metal frame, fixed, clear glass window.
Window SHGC	0.64	2009 ASHRAE Fundamentals, Ch. 15 Table 10. Value for double-pane, metal frame, fixed, clear glass window.
HVAC		
Efficiency Rating, Air Conditioner	10 SEER	Federal Standard in effect from 1990-2006. Representative of low-efficiency program participant homes.
Efficiency Rating Space Heating (Gas Furnace)	78% AFUE	Annual Fuel Utilization Efficiency – base gas furnace efficiency

[666] Building America Home Simulation Protocols (BAHSP), Available at: http://www.nrel.gov/docs/fy11osti/49246.pdf

[667] Referenced information is from 2009 ASHRAE Fundamentals, Section 16.17 Residential Ventilation.

Efficiency Rating Space Heating (Electric Resistance Heat)	COP 1.0	Coefficient of Performance for central electric resistance heating systems
Efficiency Rating Space Heating (Heat Pump)	HSPF = 7.25	Average of Federal Standards: 1992 – 1/2006: 6.8 HSPF 1/2006 – 1/2015: 7.7 HSPF
Thermostat Settings	Heating: 71 F Cooling 76 F	BAHSP, p. 49
Duct Losses	20%	Lower tier of air leakage for typical homes as cited by ENERGY STAR®[668]
Duct Insulation	R-4	
Domestic Hot Water		
Energy Factor, Electric Storage	0.9	BAHSP (p. 42) EWH with 50 gal tank, 3-inch insulation.
Energy Factor, Gas Storage	0.59	BAHSP (p. 42), midpoint between options 2 and 3
Lighting		
Share of Lighting by Type	Lamps are 66% incandescent, 21% CFL, 13% T-8 linear fluorescent	BAHSP (p. 16)

[668] ENERGY STAR®, Duct Sealing: http://www.energystar.gov/?c=home_improvement.hm_improvement_ducts

Insulation – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Ceiling Construction	2-foot-wide vaulted ceiling around the perimeter of the conditioned floor area	This modeling approach reduces simulation distortions introduced by a large vaulted ceiling area, while still exposing the attic knee walls to the conditioned living space.
Base Knee Wall Insulation	No existing insulation	Encountered insulation level drives eligibility for this measure
Improved Knee Wall Insulation	(1) Insulate to R-19, or (2) Insulate to R-30	Efficiency Measure

Ceiling Insulation – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Base Ceiling Insulation	Five ranges of encountered ceiling insulation: R-0 to R-1 R-2 to R-4 R-5 to R-8 R-9 to R-14 R-15 to R-22	Insulation level as encountered by the EESP drives eligibility for this measure
Improved Ceiling Insulation	Insulate to R-38 & R-49	Efficiency measure – retrofit insulation level

Wall Insulation – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Base Wall Insulation	R-0	Insulation level as encountered by the EESP drives eligibility for this measure
Improved Wall Insulation	R-13 & R-23	3.5” of fiberglass batt at R-3.7/in provides R-13 Full thickness of 4” cavity with open cell foam provides R-13 Full thickness of 4” cavity with open cell foam provides R-13

Floor Insulation – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Foundation	Pier and beam with vented crawlspace	Floor Insulation not a relevant measure for homes with slab foundation
Base Floor Insulation	R-0	Insulation level as encountered by the EESP drives eligibility for this measure
Change Floor Insulation	R-19	This brings existing homes in compliance with IECC 2009.
Crawlspace Insulation	R-13	This brings existing homes in compliance with IECC 2009.

Air Infiltration – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Base Air Leakage	0.9 ACH	Median infiltration value of older low-income housing sample:
Change Air Leakage	.035 ACH	Minimum allowable air exchanges assuming a 1,764 ft2 and 3-bedroom prototype home: ASHRAE 62.2 P - 2010

Radiant Barriers – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Ceiling Insulation Case 1	≤ R-19	Assumed existing insulation level
Ceiling Insulation Case 2	> R-19	Assumed existing insulation level
Base roof deck	No radiant barrier	Existing condition applicable for this measure
Change roof deck	Double-Sided, Foil: Installed radiant barrier meeting ENERGY STAR® standards	Efficiency Measure

Window Film – Prototype Home Characteristics

Shell Characteristic	Value	Source(s)
Baseline Window Characteristics – double-pane model	0.81 U-value/0.64 SHGC	U-value assuming metal framed, double-pane clear glass windows 2009 ASHRAE Fundamentals, Ch.15 Tables 4 and 10
Baseline Window Characteristics – single-pane model	1.12 U-value/0.79 SHGC	U-value assuming metal framed, single-pane clear glass windows 2009 ASHRAE Fundamentals, Ch.15 Tables 4 and 10
Change Case Window Characteristics – double-pane model	0.81 U-value/0.49 SHGC	Efficiency Measure – values based on 3M product performance and technical data
Change Case Window Characteristics – single-pane model	1.12 U-value/0.40 SHGC	Efficiency Measure – values based on 3M product performance and technical data

E.1.2. Commercial

E.1.2.1. Commercial Water Heating

Ambient Water Main (Tin) and Outside Air Temperature (T_{amb}) Calculations based on TMY3 New Orleans climate data

New Orleans	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg
Month	1	2	3	4	5	6	7	8	9	10	11	12	
Outside Air Temperature (T_{air})	49.9	55.6	64.1	69.4	75.1	80.7	81.6	82.3	77.7	68.2	65.6	54.5	**68.7**
Water Heater Inlet Water Temperature, (T_{in})	66.0	64.2	65.2	68.6	73.6	78.9	83.1	85.2	84.4	81.2	76.3	70.9	**74.8**
offset (district water) =	6.00												
ratio =	0.647												
lag =	34.8												

E.1.2.2. Duct Efficiency Improvements, Duct Insulation (SC), Cool Roofs, & Window Awnings (SC) – Prototype Building Characteristics

Building Characteristic	Building Type		
	Small Office	Stand-Alone Retail	Strip Mall
General			
Ground Area (Sq. Ft.)	7,500	15,000	7,500
# of Stories	2	1	1
Floor Area (Sq. Ft.)	15,000	15,000	7,500
Roof			
Construction	Metal Frame, > 24 in. o.c.	Metal Frame, > 24 in. o.c.	Metal Frame, > 24 in. o.c.
Ext. Finish	Roof, Built up	Roof, Built up	Roof, Built up
Ext. Color	Med (abs = 0.6)	Med (abs = 0.6)	Med (abs = 0.6)
Ext. Insulation	Varied	Varied	Varied
Add'l Insulation	No batt or radiant barrier	No batt or radiant barrier	No batt or radiant barrier
Walls			
Construction	Metal Frame, 2x6, 24 in. o.c.	Metal Frame, 2x6, 16 in. o.c.	Metal Frame, 2x4, 16 in. o.c.
Ext. Finish	Wood/Plywood	CMU	Stucco/Gunite
Ext. Color	Med (abs = 0.6)	Med (abs = 0.6)	Med (abs = 0.6)
Ext. Insulation	3/4 in. fiber bd sheathing (R-2)	3/4 in. fiber bd sheathing (R-2)	1/2 in. fiber bd sheathing (R-1.3)

Building Characteristic	Building Type		
	Small Office	Stand-Alone Retail	Strip Mall
Add'l Insulation	R-19 batt	R-11 batt	R-11 batt
Ceiling			
Construction	Acoustic Tile	Acoustic Tile	Acoustic Tile
Insulation	varied	varied	varied
Windows			
Glass Category	Double Clr/Tint 1/4", 1/2" air	Double Clr/Tint 1/4", 1/2" air	Double Clr/Tint 1/4", 1/2" air
Window Area	70% of all walls	70% of North wall; all others 0%	70% of East wall; all others 0%
Lighting			
Lighting Density (W/Sq. Ft.)	1.330	2.030	2.030
HVAC			
Cooling Source	DX Coils	DX Coils	DX Coils
System Type	Packaged Single Zone	Packaged Single Zone	Packaged Single Zone
Typ. Unit Size	11.25 – 20 tons	5.4 – 7.5 tons	< 5.4 tons
EER (Base)	8.50 EER	8.90 EER	9.70 SEER
Heating Source	Furnace	Furnace	Furnace
Typ. Unit Size	> 225 kBTUh	< 225 kBTUh	< 225 kBTUh
Efficiency (AFUE)	0.806	0.780	0.780
Fans			
Min. Design Flow (cfm/ft^2)	0.50	0.50	0.50
Cycle Fans at Night?	Cycle Fans (no OA at night)	Cycle Fans (no OA at night)	Cycle Fans (no OA at night)
DHW			
Fuel	Natural Gas	Natural Gas	Natural Gas
Type	Storage	Storage	Storage
Tank Insulation R-Value	12.00	12.00	12.00
Tank Capacity (gal)	39	21	11

E.1.2.3. HVAC

The tables below provide the eQuest Equivalent Full Load Hours (EFLH) model results for various building types found in New Orleans. EFLH values developed in eQuest were then normalized with El Dorado, AR EFLH.

eQuest Model EFLH Results

Building Type	El Dorado		New Orleans	
	$EFLH_c$	$EFLH_h$	$EFLH_c$	$EFLH_h$
Fast Food	2,111	411	3,013	178
Grocery	1,544	537	1,703	285
Health Clinic	1,317	510	1,451	325
Large Office	1,684	879	1,598	501
Lodging	5,833	588	7,647	372
Full Menu Restaurant	2,070	509	2,900	217
Retail	2,424	588	3,305	372
School	1,209	420	1,672	167
Small Office	1,564	115	2,098	37
University	1,755	771	1,799	602

EFHL Normalized Multipliers

Building Type	El Dorado		New Orleans	
	$EFLH_c$	$EFLH_h$	$EFLH_c$	$EFLH_h$
Fast Food	1.00	1.00	1.43	0.43
Grocery	1.00	1.00	1.10	0.53
Health Clinic	1.00	1.00	1.10	0.64
Large Office	1.00	1.00	0.95	0.57
Lodging	1.00	1.00	1.31	0.63
Full Menu Restaurant	1.00	1.00	1.40	0.43
Retail	1.00	1.00	1.36	0.63
School	1.00	1.00	1.38	0.40
Small Office	1.00	1.00	1.34	0.33
University	1.00	1.00	1.02	0.78

E.1.2.4. Lighting

The table below shows logger counts, standard deviations, and compare original AR TRM6 hours with figures derived from direct monitoring.

Commercial Lighting Updates

Facility or Space Type	Count of Loggers	ARM TRM 6 hours	New Orleans Recommended Value
Leisure Dining: Bar Area	12		2,676.0
Corridor/Hallway/Stairwell	39		5,537.3
Education: College/University		3,577.0	3,577.0
Education: K-12	9	2,777.0	2,333.5
Exterior		3,996.0	4,319.0
Food Sales: 24-Hour Supermarket		6,900.0	6,900.0
Food Sales: Non 24-Hour Supermarket	5	4,706.0	2,058.2
Food Service: Fast Food	11	6,188.0	6,473.4
Food Service: Sit-Down Restaurant	13	4,368.0	4,730.6
Health Care: In-Patient	3	5,730.0	4,019.4
Health Care: Nursing Home		4,271.0	4,271.0
Health Care: Out-Patient		3,386.0	3,386.0
Convenience Store (non-24 hour)	22		4,244.8
Lodging (Hotel/Motel/Dorm): Common Areas	22	6,630.0	4,126.9
Lodging (Hotel/Motel/Dorm): Room	13	3,055.0	3,369.9
Manufacturing		5,740.0	5,740.0
Multi-family Housing: Common Areas	24	4,772.0	5,703.4
Non-Warehouse Storage (Generic)	11		4,206.5
Office	27	3,737.0	5,158.5
Office (attached to other facility)	36		4,728.4
Parking Structure		7,884.0	7,884.0
Public Assembly		2,638.0	2,638.0
Public Order and Safety		3,472.0	3,472.0
Religious Gathering	8	1,824.0	3,174.3
Restroom (Generic)	11		3,515.6
Retail: Enclosed Mall		4,813.0	4,813.0
Retail: Freestanding	52	3,668.0	3,514.8
Retail: Other	4	4,527.0	4,311.8
Retail: Strip Mall		3,965.0	3,965.0
Service: Excluding Food		3,406.0	3,406.0
Warehouse: Non-Refrigerated	9	3,501.0	2,416.7
Warehouse: Offices	4		2,791.8
Warehouse: Refrigerated		3,798.0	3,798.0

E.1.2.4.1. Lighting Power Density

ASHRAE 90.1-2007 Lighting Power Densities (LPD) – Building Area Method[669]

Building Area Type	LPD (W/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Heathcare-Clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Movie Theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1

[669] ANSI/ASHRAE/IESNA Standard 90.1-2007, Table 9.5.1

Transportation	1.0
Warehouse	0.8
Workshop	1.4

ASHRAE 90.1-2007 Lighting Power Densities (LPD) – Space-by-Space Method by Space Types[670]

Common Space Types[671]		**LPD (W/ft^2)**
Office- Enclosed		1.1
Office-Open Plan		1.1
Conference/Meeting/Multipurpose		1.3
Classroom/Lecture/Training		1.4
	For Penitentiary	1.3
Lobby		1.3
	For Hotel	1.1
	For Performing Arts Center	3.3
	For Motion Picture Theater	1.1
Audiences/Seating Area		0.9
	For Gymnasium	0.4
	For Exercise Center	0.3
	For Convention Center	0.7
	For Penitentiary	0.7
	For Religious Building	1.7
	For Sports Area	0.4
	For Performing Arts Theater	2.6
	For Motion Picture Theater	1.2
	For Transportation	0.5
Atrium- First Three Floors		0.6

[670] ANSI/ASHRAE/IESNA Standard 90.1-2007, Table 9.6.1

[671] In cases where both a common space type and a building-specific space type are listed, the building-specific space type shall apply.

Atrium- Additional Floors		0.2
Lounge/Reception		1.2
	For Hospital	0.8
Dining Area		0.9
	For Penitentiary	1.3
	For Hotel	1.3
	For Motel	1.2
	For Bar Lounge/Leisure Dining	1.4
	For Family Dining	2.1
Food Preparation		1.2
Laboratory		1.4
Restrooms		0.9
Dressing/Locker/Fitting Room		0.6
Corridor/Transition		0.5
	For Hospital	1.0
	For Manufacturing Facility	0.5
Stairs- Active		0.6
Active Storage		0.8
	For Hospital	0.9
Inactive Storage		0.3
	For Museum	0.8
Electrical/Mechanical		1.5
Workshop		1.9
Sales Area (for accent lighting)		1.7

ASHRAE 90.1-2007 Lighting Power Densities (LPD) – Space-by-Space Method by Building-Specific Space Types[672]

Building-Specific Space Types[673]	**LPD (W/ft^2)**

[672] ANSI/ASHRAE/IESNA Standard 90.1-2007, Table 9.6.1

[673] In cases where both a common space type and a building-specific space type are listed, the building-specific space type shall apply.

Gymnasium/Exercise Center	Playing Area	1.4
	Exercise Area	0.9
Courthouse/Police Station/Penitentiary	Courtroom	1.9
	Confinement Cells	0.9
	Judges' Chambers	1.3
Fire Stations	Engine Room	0.8
	Sleeping Quarters	0.3
Post Office- Sorting Area		1.2
Convention Center- Exhibit Space		1.3
Library	Card File and Cataloging	1.1
	Stacks	1.7
	Reading Area	1.2
Hospital	Emergency	2.7
	Recovery	0.8
	Nurses' Station	1.0
	Exam/Treatment	1.5
	Pharmacy	1.2
	Patient Room	0.7
	Operating Room	2.2
	Nursery	0.6
	Medical Supply	1.4
	Physical Therapy	0.9
	Radiology	0.4
	Laundry-Washing	0.6
Automotive- Service/Repair		0.7
Manufacturing	Low Bay *<25ft floor to ceiling height)	1.2
	High Bay (>25ft floor to ceiling height)	1.7
	Detailed manufacturing	2.1
	Equipment Room	1.2
	Control Room	0.5
Hotel/Motel Guest Rooms		1.1
Dormitory- Living Quarters		1.1
Museum	General Exhibition	1
	Restoration	1.7

Bank/Office- Banking Activity Area		1.5
Religious Building	Worship Pulpit, Choir	2.4
	Fellowship Hall	0.9
Retail	Sales Area (for accent lighting)	1.7
	Mall Concourse	1.7
Sports Arena	Ring Sports Area	2.7
	Court Sports Area	2.3
	Indoor Playing Field Area	1.4
Warehouse	Fine Material Storage	1.4
	Medium/Bulky Material Storage	0.9
Parking Garage- Garage Area		0.2
Transportation	Airport- Concourse	0.6
	Air/Train/Bus- Baggage Area	1.0
	Terminal- Ticket Counter	1.5

ASHRAE 90.1-2007 Lighting Power Densities (LPD) – Building Exteriors[674,675]

Tradable/ Non-tradable	Exterior Space Type		LPD
Tradable Surfaces	Uncovered Parking Areas- Parking lots and drives		0.15 Wft^2
	Building Grounds	Walkways <10ft wide	1.0 W/linear ft
		Walkways >10ftwide	0.02 W/ft^2
		Stairways	1 ft^2

[674] ANSI/ASHRAE/IESNA Standard 90.1-2007, Table 9.4.5

[675] Exterior Building Lighting Power: The total exterior lighting power allowance for all exterior building applications is the sum of the individual lighting power densities permitted in Table 4 for these application plus an additional unrestricted allowance of 5% of that sum. The trade-offs are allowed only among exterior lighting applications listed in Table 4 "Tradable Surfaces" section.

	Building Entrances and Exits	Main entries	30 W/linear ft (of door width)
		Other doors	20 W/linear ft (of door width)
	Canopies and Overhangs- Canopies (free standing, attached & overhangs)		1.25 W/ft^2
	Outdoor Sales	Open areas (including vehicle sales lots)	0.5 W/ft^2
		Street frontage for vehicle sales lots (in addition to above)	20 W/linear ft.
Nontradable Surfaces	Building Facades	For each illuminated wall or surface OR	0.2 W/ft^2
		For each illuminated wall or surface length	5.0 W/linear ft
	Automated Teller Machines and Night Depositories	Per location	270 W
		Per additional ATM per location	90 W
	Entrances and Gatehouse Inspection Stations at Guarded Facilities- Uncovered areas (for covered areas use Canopies/Overhangs)		1.25 W/ft^2
	Loading Areas for Emergency Service Vehicles- Uncovered areas (for covered areas use Canopies/Overhangs)		0.5 W/ft^2
	Drive-up Windows at Fast Food Restaurants- per drive-through		400 W
	Parking near 24-hour Retail Entrances- Per main entry		800 W

E.1.2.4.1. Wattage Tables

The table below presents standard wattages.

Standard Wattage Table

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED-SCRW		Integrated Ballast LEDs						
LED001-SCRW	LEDINT1W	Integrated Ballast LED, (1) 1W screw-in lamp/base, any bulb shape	1W LED - Int. Ballast	Electronic	N/A	N/A	1	9
LED002-SCRW	LEDINT2W	Integrated Ballast LED, (1) 2W screw-in lamp/base, any bulb shape	2W LED - Int. Ballast	Electronic	N/A	N/A	2	9
LED003-SCRW	LEDINT3W	Integrated Ballast LED, (1) 3W screw-in lamp/base, any bulb shape	3W LED - Int. Ballast	Electronic	N/A	N/A	3	9
LED004-SCRW	LEDINT4W	Integrated Ballast LED, (1) 4W screw-in lamp/base, any bulb shape	4W LED - Int. Ballast	Electronic	N/A	N/A	4	9
LED005-SCRW	LEDINT5W	Integrated Ballast LED, (1) 5W screw-in lamp/base, any bulb shape	5W LED - Int. Ballast	Electronic	N/A	N/A	5	9
LED006-SCRW	LEDINT6W	Integrated Ballast LED, (1) 6W screw-in lamp/base, any bulb shape	6W LED - Int. Ballast	Electronic	N/A	N/A	6	9
LED007-SCRW	LEDINT7W	Integrated Ballast LED, (1) 7W screw-in lamp/base, any bulb shape	7W LED - Int. Ballast	Electronic	N/A	N/A	7	9

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED008-SCRW	LEDINT8W	Integrated Ballast LED, (1) 8W screw-in lamp/base, any bulb shape	8W LED - Int. Ballast	Electronic	N/A	N/A	8	9
LED009-SCRW	LEDINT9W	Integrated Ballast LED, (1) 9W screw-in lamp/base, any bulb shape	9W LED - Int. Ballast	Electronic	N/A	N/A	9	9
LED010-SCRW	LEDINT10W	Integrated Ballast LED, (1) 10W screw-in lamp/base, any bulb shape	10W LED - Int. Ballast	Electronic	N/A	N/A	10	9
LED011-SCRW	LEDINT11W	Integrated Ballast LED, (1) 11W screw-in lamp/base, any bulb shape	11W LED - Int. Ballast	Electronic	N/A	N/A	11	9
LED012-SCRW	LEDINT12W	Integrated Ballast LED, (1) 12W screw-in lamp/base, any bulb shape	12W LED - Int. Ballast	Electronic	N/A	N/A	12	9
LED013-SCRW	LEDINT13W	Integrated Ballast LED, (1) 13W screw-in lamp/base, any bulb shape	13W LED - Int. Ballast	Electronic	N/A	N/A	13	9
LED014-SCRW	LEDINT14W	Integrated Ballast LED, (1) 14W screw-in lamp/base, any bulb shape	14W LED - Int. Ballast	Electronic	N/A	N/A	14	9
LED015-SCRW	LEDINT15W	Integrated Ballast LED, (1) 15W screw-in lamp/base, any bulb shape	15W LED - Int. Ballast	Electronic	N/A	N/A	15	9
LED016-SCRW	LEDINT16W	Integrated Ballast LED, (1) 16W screw-in lamp/base, any bulb shape	16W LED - Int. Ballast	Electronic	N/A	N/A	16	9

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED017-SCRW	LEDINT17W	Integrated Ballast LED, (1) 17W screw-in lamp/base, any bulb shape	17W LED - Int. Ballast	Electronic	N/A	N/A	17	9
LED018-SCRW	LEDINT18W	Integrated Ballast LED, (1) 18W screw-in lamp/base, any bulb shape	18W LED - Int. Ballast	Electronic	N/A	N/A	18	9
LED019-SCRW	LEDINT19W	Integrated Ballast LED, (1) 19W screw-in lamp/base, any bulb shape	19W LED - Int. Ballast	Electronic	N/A	N/A	19	9
LED020-SCRW	LEDINT20W	Integrated Ballast LED, (1) 20W screw-in lamp/base, any bulb shape	20W LED - Int. Ballast	Electronic	N/A	N/A	20	9
LED021-SCRW	LEDINT21W	Integrated Ballast LED, (1) 21W screw-in lamp/base, any bulb shape	21W LED - Int. Ballast	Electronic	N/A	N/A	21	9
LED022-SCRW	LEDINT22W	Integrated Ballast LED, (1) 22W screw-in lamp/base, any bulb shape	22W LED - Int. Ballast	Electronic	N/A	N/A	22	9
LED023-SCRW	LEDINT23W	Integrated Ballast LED, (1) 23W screw-in lamp/base, any bulb shape	23W LED - Int. Ballast	Electronic	N/A	N/A	23	9
LED024-SCRW	LEDINT24W	Integrated Ballast LED, (1) 24W screw-in lamp/base, any bulb shape	24W LED - Int. Ballast	Electronic	N/A	N/A	24	9
LED025-SCRW	LEDINT25W	Integrated Ballast LED, (1) 25W screw-in lamp/base, any bulb shape	25W LED - Int. Ballast	Electronic	N/A	N/A	25	9

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED026-SCRW	LEDINT26W	Integrated Ballast LED, (1) 26W screw-in lamp/base, any bulb shape	26W LED - Int. Ballast	Electronic	N/A	N/A	26	9
LED027-SCRW	LEDINT27W	Integrated Ballast LED, (1) 27W screw-in lamp/base, any bulb shape	27W LED - Int. Ballast	Electronic	N/A	N/A	27	9
LED028-SCRW	LEDINT28W	Integrated Ballast LED, (1) 28W screw-in lamp/base, any bulb shape	28W LED - Int. Ballast	Electronic	N/A	N/A	28	9
LED029-SCRW	LEDINT29W	Integrated Ballast LED, (1) 29W screw-in lamp/base, any bulb shape	29W LED - Int. Ballast	Electronic	N/A	N/A	29	9
LED030-SCRW	LEDINT30W	Integrated Ballast LED, (1) 30W screw-in lamp/base, any bulb shape	30W LED - Int. Ballast	Electronic	N/A	N/A	30	9
LED031-SCRW	LEDINT31W	Integrated Ballast LED, (1) 31W screw-in lamp/base, any bulb shape	31W LED - Int. Ballast	Electronic	N/A	N/A	31	9
LED032-SCRW	LEDINT32W	Integrated Ballast LED, (1) 32W screw-in lamp/base, any bulb shape	32W LED - Int. Ballast	Electronic	N/A	N/A	32	9
LED033-SCRW	LEDINT33W	Integrated Ballast LED, (1) 33W screw-in lamp/base, any bulb shape	33W LED - Int. Ballast	Electronic	N/A	N/A	33	9
LED034-SCRW	LEDINT34W	Integrated Ballast LED, (1) 34W screw-in lamp/base, any bulb shape	34W LED - Int. Ballast	Electronic	N/A	N/A	34	9

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED035-SCRW	LEDINT35W	Integrated Ballast LED, (1) 35W screw-in lamp/base, any bulb shape	35W LED - Int. Ballast	Electronic	N/A	N/A	35	9
LED036-SCRW	LEDINT36W	Integrated Ballast LED, (1) 36W screw-in lamp/base, any bulb shape	36W LED - Int. Ballast	Electronic	N/A	N/A	36	9
LED037-SCRW	LEDINT37W	Integrated Ballast LED, (1) 37W screw-in lamp/base, any bulb shape	37W LED - Int. Ballast	Electronic	N/A	N/A	37	9
LED038-SCRW	LEDINT38W	Integrated Ballast LED, (1) 38W screw-in lamp/base, any bulb shape	38W LED - Int. Ballast	Electronic	N/A	N/A	38	9
LED039-SCRW	LEDINT39W	Integrated Ballast LED, (1) 39W screw-in lamp/base, any bulb shape	39W LED - Int. Ballast	Electronic	N/A	N/A	39	9
LED040-SCRW	LEDINT40W	Integrated Ballast LED, (1) 40W screw-in lamp/base, any bulb shape	40W LED - Int. Ballast	Electronic	N/A	N/A	40	9
LED041-SCRW	LEDINT41W	Integrated Ballast LED, (1) 41W screw-in lamp/base, any bulb shape	41W LED - Int. Ballast	Electronic	N/A	N/A	41	9
LED042-SCRW	LEDINT42W	Integrated Ballast LED, (1) 42W screw-in lamp/base, any bulb shape	42W LED - Int. Ballast	Electronic	N/A	N/A	42	9
LED043-SCRW	LEDINT43W	Integrated Ballast LED, (1) 43W screw-in lamp/base, any bulb shape	43W LED - Int. Ballast	Electronic	N/A	N/A	43	9

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED044-SCRW	LEDINT44W	Integrated Ballast LED, (1) 44W screw-in lamp/base, any bulb shape	44W LED - Int. Ballast	Electronic	N/A	N/A	44	9
LED045-SCRW	LEDINT45W	Integrated Ballast LED, (1) 45W screw-in lamp/base, any bulb shape	45W LED - Int. Ballast	Electronic	N/A	N/A	45	9
LED046-SCRW	LEDINT46W	Integrated Ballast LED, (1) 46W screw-in lamp/base, any bulb shape	46W LED - Int. Ballast	Electronic	N/A	N/A	46	9
LED047-SCRW	LEDINT47W	Integrated Ballast LED, (1) 47W screw-in lamp/base, any bulb shape	47W LED - Int. Ballast	Electronic	N/A	N/A	47	9
LED048-SCRW	LEDINT48W	Integrated Ballast LED, (1) 48W screw-in lamp/base, any bulb shape	48W LED - Int. Ballast	Electronic	N/A	N/A	48	9
LED049-SCRW	LEDINT49W	Integrated Ballast LED, (1) 49W screw-in lamp/base, any bulb shape	49W LED - Int. Ballast	Electronic	N/A	N/A	49	9
LED050-SCRW	LEDINT50W	Integrated Ballast LED, (1) 50W screw-in lamp/base, any bulb shape	50W LED - Int. Ballast	Electronic	N/A	N/A	50	9
LED-FIXT		Non-Integrated Ballast LEDs						
LED001-FIXT	LED1W	Non-Integrated Ballast LED, 1W, any bulb shape, any application	1W LED - Non-Int. Ballast	Electronic	N/A	N/A	1	15
LED002-FIXT	LED2W	Non-Integrated Ballast LED, 2W, any bulb shape, any application	2W LED - Non-Int. Ballast	Electronic	N/A	N/A	2	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED003-FIXT	LED3W	Non-Integrated Ballast LED, 3W, any bulb shape, any application	3W LED - Non-Int. Ballast	Electronic	N/A	N/A	3	15
LED004-FIXT	LED4W	Non-Integrated Ballast LED, 4W, any bulb shape, any application	4W LED - Non-Int. Ballast	Electronic	N/A	N/A	4	15
LED005-FIXT	LED5W	Non-Integrated Ballast LED, 5W, any bulb shape, any application	5W LED - Non-Int. Ballast	Electronic	N/A	N/A	5	15
LED006-FIXT	LED6W	Non-Integrated Ballast LED, 6W, any bulb shape, any application	6W LED - Non-Int. Ballast	Electronic	N/A	N/A	6	15
LED007-FIXT	LED7W	Non-Integrated Ballast LED, 7W, any bulb shape, any application	7W LED - Non-Int. Ballast	Electronic	N/A	N/A	7	15
LED008-FIXT	LED8W	Non-Integrated Ballast LED, 8W, any bulb shape, any application	8W LED - Non-Int. Ballast	Electronic	N/A	N/A	8	15
LED009-FIXT	LED9W	Non-Integrated Ballast LED, 9W, any bulb shape, any application	9W LED - Non-Int. Ballast	Electronic	N/A	N/A	9	15
LED010-FIXT	LED10W	Non-Integrated Ballast LED, 10W, any bulb shape, any application	10W LED - Non-Int. Ballast	Electronic	N/A	N/A	10	15
LED011-FIXT	LED11W	Non-Integrated Ballast LED, 11W, any bulb shape, any application	11W LED - Non-Int. Ballast	Electronic	N/A	N/A	11	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED012-FIXT	LED12W	Non-Integrated Ballast LED, 12W, any bulb shape, any application	12W LED - Non-Int. Ballast	Electronic	N/A	N/A	12	15
LED013-FIXT	LED13W	Non-Integrated Ballast LED, 13W, any bulb shape, any application	13W LED - Non-Int. Ballast	Electronic	N/A	N/A	13	15
LED014-FIXT	LED14W	Non-Integrated Ballast LED, 14W, any bulb shape, any application	14W LED - Non-Int. Ballast	Electronic	N/A	N/A	14	15
LED015-FIXT	LED15W	Non-Integrated Ballast LED, 15W, any bulb shape, any application	15W LED - Non-Int. Ballast	Electronic	N/A	N/A	15	15
LED016-FIXT	LED16W	Non-Integrated Ballast LED, 16W, any bulb shape, any application	16W LED - Non-Int. Ballast	Electronic	N/A	N/A	16	15
LED017-FIXT	LED17W	Non-Integrated Ballast LED, 17W, any bulb shape, any application	17W LED - Non-Int. Ballast	Electronic	N/A	N/A	17	15
LED018-FIXT	LED18W	Non-Integrated Ballast LED, 18W, any bulb shape, any application	18W LED - Non-Int. Ballast	Electronic	N/A	N/A	18	15
LED019-FIXT	LED19W	Non-Integrated Ballast LED, 19W, any bulb shape, any application	19W LED - Non-Int. Ballast	Electronic	N/A	N/A	19	15
LED020-FIXT	LED20W	Non-Integrated Ballast LED, 20W, any bulb shape, any application	20W LED - Non-Int. Ballast	Electronic	N/A	N/A	20	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED021-FIXT	LED21W	Non-Integrated Ballast LED, 21W, any bulb shape, any application	21W LED - Non-Int. Ballast	Electronic	N/A	N/A	21	15
LED022-FIXT	LED22W	Non-Integrated Ballast LED, 22W, any bulb shape, any application	22W LED - Non-Int. Ballast	Electronic	N/A	N/A	22	15
LED023-FIXT	LED23W	Non-Integrated Ballast LED, 23W, any bulb shape, any application	23W LED - Non-Int. Ballast	Electronic	N/A	N/A	23	15
LED024-FIXT	LED24W	Non-Integrated Ballast LED, 24W, any bulb shape, any application	24W LED - Non-Int. Ballast	Electronic	N/A	N/A	24	15
LED025-FIXT	LED25W	Non-Integrated Ballast LED, 25W, any bulb shape, any application	25W LED - Non-Int. Ballast	Electronic	N/A	N/A	25	15
LED026-FIXT	LED26W	Non-Integrated Ballast LED, 26W, any bulb shape, any application	26W LED - Non-Int. Ballast	Electronic	N/A	N/A	26	15
LED027-FIXT	LED27W	Non-Integrated Ballast LED, 27W, any bulb shape, any application	27W LED - Non-Int. Ballast	Electronic	N/A	N/A	27	15
LED028-FIXT	LED28W	Non-Integrated Ballast LED, 28W, any bulb shape, any application	28W LED - Non-Int. Ballast	Electronic	N/A	N/A	28	15
LED029-FIXT	LED29W	Non-Integrated Ballast LED, 29W, any bulb shape, any application	29W LED - Non-Int. Ballast	Electronic	N/A	N/A	29	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED030-FIXT	LED30W	Non-Integrated Ballast LED, 30W, any bulb shape, any application	30W LED - Non-Int. Ballast	Electronic	N/A	N/A	30	15
LED031-FIXT	LED31W	Non-Integrated Ballast LED, 31W, any bulb shape, any application	31W LED - Non-Int. Ballast	Electronic	N/A	N/A	31	15
LED032-FIXT	LED32W	Non-Integrated Ballast LED, 32W, any bulb shape, any application	32W LED - Non-Int. Ballast	Electronic	N/A	N/A	32	15
LED033-FIXT	LED33W	Non-Integrated Ballast LED, 33W, any bulb shape, any application	33W LED - Non-Int. Ballast	Electronic	N/A	N/A	33	15
LED034-FIXT	LED34W	Non-Integrated Ballast LED, 34W, any bulb shape, any application	34W LED - Non-Int. Ballast	Electronic	N/A	N/A	34	15
LED035-FIXT	LED35W	Non-Integrated Ballast LED, 35W, any bulb shape, any application	35W LED - Non-Int. Ballast	Electronic	N/A	N/A	35	15
LED036-FIXT	LED36W	Non-Integrated Ballast LED, 36W, any bulb shape, any application	36W LED - Non-Int. Ballast	Electronic	N/A	N/A	36	15
LED037-FIXT	LED37W	Non-Integrated Ballast LED, 37W, any bulb shape, any application	37W LED - Non-Int. Ballast	Electronic	N/A	N/A	37	15
LED038-FIXT	LED38W	Non-Integrated Ballast LED, 38W, any bulb shape, any application	38W LED - Non-Int. Ballast	Electronic	N/A	N/A	38	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED039-FIXT	LED39W	Non-Integrated Ballast LED, 39W, any bulb shape, any application	39W LED - Non-Int. Ballast	Electronic	N/A	N/A	39	15
LED040-FIXT	LED40W	Non-Integrated Ballast LED, 40W, any bulb shape, any application	40W LED - Non-Int. Ballast	Electronic	N/A	N/A	40	15
LED041-FIXT	LED41W	Non-Integrated Ballast LED, 41W, any bulb shape, any application	41W LED - Non-Int. Ballast	Electronic	N/A	N/A	41	15
LED042-FIXT	LED42W	Non-Integrated Ballast LED, 42W, any bulb shape, any application	42W LED - Non-Int. Ballast	Electronic	N/A	N/A	42	15
LED043-FIXT	LED43W	Non-Integrated Ballast LED, 43W, any bulb shape, any application	43W LED - Non-Int. Ballast	Electronic	N/A	N/A	43	15
LED044-FIXT	LED44W	Non-Integrated Ballast LED, 44W, any bulb shape, any application	44W LED - Non-Int. Ballast	Electronic	N/A	N/A	44	15
LED045-FIXT	LED45W	Non-Integrated Ballast LED, 45W, any bulb shape, any application	45W LED - Non-Int. Ballast	Electronic	N/A	N/A	45	15
LED046-FIXT	LED46W	Non-Integrated Ballast LED, 46W, any bulb shape, any application	46W LED - Non-Int. Ballast	Electronic	N/A	N/A	46	15
LED047-FIXT	LED47W	Non-Integrated Ballast LED, 47W, any bulb shape, any application	47W LED - Non-Int. Ballast	Electronic	N/A	N/A	47	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED048-FIXT	LED48W	Non-Integrated Ballast LED, 48W, any bulb shape, any application	48W LED - Non-Int. Ballast	Electronic	N/A	N/A	48	15
LED049-FIXT	LED49W	Non-Integrated Ballast LED, 49W, any bulb shape, any application	49W LED - Non-Int. Ballast	Electronic	N/A	N/A	49	15
LED050-FIXT	LED50W	Non-Integrated Ballast LED, 50W, any bulb shape, any application	50W LED - Non-Int. Ballast	Electronic	N/A	N/A	50	15
LED051-FIXT	LED51W	Non-Integrated Ballast LED, 51W, any bulb shape, any application	51W LED - Non-Int. Ballast	Electronic	N/A	N/A	51	15
LED052-FIXT	LED52W	Non-Integrated Ballast LED, 52W, any bulb shape, any application	52W LED - Non-Int. Ballast	Electronic	N/A	N/A	52	15
LED053-FIXT	LED53W	Non-Integrated Ballast LED, 53W, any bulb shape, any application	53W LED - Non-Int. Ballast	Electronic	N/A	N/A	53	15
LED054-FIXT	LED54W	Non-Integrated Ballast LED, 54W, any bulb shape, any application	54W LED - Non-Int. Ballast	Electronic	N/A	N/A	54	15
LED055-FIXT	LED55W	Non-Integrated Ballast LED, 55W, any bulb shape, any application	55W LED - Non-Int. Ballast	Electronic	N/A	N/A	55	15
LED056-FIXT	LED56W	Non-Integrated Ballast LED, 56W, any bulb shape, any application	56W LED - Non-Int. Ballast	Electronic	N/A	N/A	56	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED057-FIXT	LED57W	Non-Integrated Ballast LED, 57W, any bulb shape, any application	57W LED - Non-Int. Ballast	Electronic	N/A	N/A	57	15
LED058-FIXT	LED58W	Non-Integrated Ballast LED, 58W, any bulb shape, any application	58W LED - Non-Int. Ballast	Electronic	N/A	N/A	58	15
LED059-FIXT	LED59W	Non-Integrated Ballast LED, 59W, any bulb shape, any application	59W LED - Non-Int. Ballast	Electronic	N/A	N/A	59	15
LED060-FIXT	LED60W	Non-Integrated Ballast LED, 60W, any bulb shape, any application	60W LED - Non-Int. Ballast	Electronic	N/A	N/A	60	15
LED061-FIXT	LED61W	Non-Integrated Ballast LED, 61W, any bulb shape, any application	61W LED - Non-Int. Ballast	Electronic	N/A	N/A	61	15
LED062-FIXT	LED62W	Non-Integrated Ballast LED, 62W, any bulb shape, any application	62W LED - Non-Int. Ballast	Electronic	N/A	N/A	62	15
LED063-FIXT	LED63W	Non-Integrated Ballast LED, 63W, any bulb shape, any application	63W LED - Non-Int. Ballast	Electronic	N/A	N/A	63	15
LED064-FIXT	LED64W	Non-Integrated Ballast LED, 64W, any bulb shape, any application	64W LED - Non-Int. Ballast	Electronic	N/A	N/A	64	15
LED065-FIXT	LED65W	Non-Integrated Ballast LED, 65W, any bulb shape, any application	65W LED - Non-Int. Ballast	Electronic	N/A	N/A	65	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED066-FIXT	LED66W	Non-Integrated Ballast LED, 66W, any bulb shape, any application	66W LED - Non-Int. Ballast	Electronic	N/A	N/A	66	15
LED067-FIXT	LED67W	Non-Integrated Ballast LED, 67W, any bulb shape, any application	67W LED - Non-Int. Ballast	Electronic	N/A	N/A	67	15
LED068-FIXT	LED68W	Non-Integrated Ballast LED, 68W, any bulb shape, any application	68W LED - Non-Int. Ballast	Electronic	N/A	N/A	68	15
LED069-FIXT	LED69W	Non-Integrated Ballast LED, 69W, any bulb shape, any application	69W LED - Non-Int. Ballast	Electronic	N/A	N/A	69	15
LED070-FIXT	LED70W	Non-Integrated Ballast LED, 70W, any bulb shape, any application	70W LED - Non-Int. Ballast	Electronic	N/A	N/A	70	15
LED071-FIXT	LED71W	Non-Integrated Ballast LED, 71W, any bulb shape, any application	71W LED - Non-Int. Ballast	Electronic	N/A	N/A	71	15
LED072-FIXT	LED72W	Non-Integrated Ballast LED, 72W, any bulb shape, any application	72W LED - Non-Int. Ballast	Electronic	N/A	N/A	72	15
LED073-FIXT	LED73W	Non-Integrated Ballast LED, 73W, any bulb shape, any application	73W LED - Non-Int. Ballast	Electronic	N/A	N/A	73	15
LED074-FIXT	LED74W	Non-Integrated Ballast LED, 74W, any bulb shape, any application	74W LED - Non-Int. Ballast	Electronic	N/A	N/A	74	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED075-FIXT	LED75W	Non-Integrated Ballast LED, 75W, any bulb shape, any application	75W LED - Non-Int. Ballast	Electronic	N/A	N/A	75	15
LED076-FIXT	LED76W	Non-Integrated Ballast LED, 76W, any bulb shape, any application	76W LED - Non-Int. Ballast	Electronic	N/A	N/A	76	15
LED077-FIXT	LED77W	Non-Integrated Ballast LED, 77W, any bulb shape, any application	77W LED - Non-Int. Ballast	Electronic	N/A	N/A	77	15
LED078-FIXT	LED78W	Non-Integrated Ballast LED, 78W, any bulb shape, any application	78W LED - Non-Int. Ballast	Electronic	N/A	N/A	78	15
LED079-FIXT	LED79W	Non-Integrated Ballast LED, 79W, any bulb shape, any application	79W LED - Non-Int. Ballast	Electronic	N/A	N/A	79	15
LED080-FIXT	LED80W	Non-Integrated Ballast LED, 80W, any bulb shape, any application	80W LED - Non-Int. Ballast	Electronic	N/A	N/A	80	15
LED081-FIXT	LED81W	Non-Integrated Ballast LED, 81W, any bulb shape, any application	81W LED - Non-Int. Ballast	Electronic	N/A	N/A	81	15
LED082-FIXT	LED82W	Non-Integrated Ballast LED, 82W, any bulb shape, any application	82W LED - Non-Int. Ballast	Electronic	N/A	N/A	82	15
LED083-FIXT	LED83W	Non-Integrated Ballast LED, 83W, any bulb shape, any application	83W LED - Non-Int. Ballast	Electronic	N/A	N/A	83	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED084-FIXT	LED84W	Non-Integrated Ballast LED, 84W, any bulb shape, any application	84W LED - Non-Int. Ballast	Electronic	N/A	N/A	84	15
LED085-FIXT	LED85W	Non-Integrated Ballast LED, 85W, any bulb shape, any application	85W LED - Non-Int. Ballast	Electronic	N/A	N/A	85	15
LED086-FIXT	LED86W	Non-Integrated Ballast LED, 86W, any bulb shape, any application	86W LED - Non-Int. Ballast	Electronic	N/A	N/A	86	15
LED087-FIXT	LED87W	Non-Integrated Ballast LED, 87W, any bulb shape, any application	87W LED - Non-Int. Ballast	Electronic	N/A	N/A	87	15
LED088-FIXT	LED88W	Non-Integrated Ballast LED, 88W, any bulb shape, any application	88W LED - Non-Int. Ballast	Electronic	N/A	N/A	88	15
LED089-FIXT	LED89W	Non-Integrated Ballast LED, 89W, any bulb shape, any application	89W LED - Non-Int. Ballast	Electronic	N/A	N/A	89	15
LED090-FIXT	LED90W	Non-Integrated Ballast LED, 90W, any bulb shape, any application	90W LED - Non-Int. Ballast	Electronic	N/A	N/A	90	15
LED091-FIXT	LED91W	Non-Integrated Ballast LED, 91W, any bulb shape, any application	91W LED - Non-Int. Ballast	Electronic	N/A	N/A	91	15
LED092-FIXT	LED92W	Non-Integrated Ballast LED, 92W, any bulb shape, any application	92W LED - Non-Int. Ballast	Electronic	N/A	N/A	92	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED093-FIXT	LED93W	Non-Integrated Ballast LED, 93W, any bulb shape, any application	93W LED - Non-Int. Ballast	Electronic	N/A	N/A	93	15
LED094-FIXT	LED94W	Non-Integrated Ballast LED, 94W, any bulb shape, any application	94W LED - Non-Int. Ballast	Electronic	N/A	N/A	94	15
LED095-FIXT	LED95W	Non-Integrated Ballast LED, 95W, any bulb shape, any application	95W LED - Non-Int. Ballast	Electronic	N/A	N/A	95	15
LED096-FIXT	LED96W	Non-Integrated Ballast LED, 96W, any bulb shape, any application	96W LED - Non-Int. Ballast	Electronic	N/A	N/A	96	15
LED097-FIXT	LED97W	Non-Integrated Ballast LED, 97W, any bulb shape, any application	97W LED - Non-Int. Ballast	Electronic	N/A	N/A	97	15
LED098-FIXT	LED98W	Non-Integrated Ballast LED, 98W, any bulb shape, any application	98W LED - Non-Int. Ballast	Electronic	N/A	N/A	98	15
LED099-FIXT	LED99W	Non-Integrated Ballast LED, 99W, any bulb shape, any application	99W LED - Non-Int. Ballast	Electronic	N/A	N/A	99	15
LED100-FIXT	LED100W	Non-Integrated Ballast LED, 100W, any bulb shape, any application	100W LED - Non-Int. Ballast	Electronic	N/A	N/A	100	15
LED101-FIXT	LED101W	Non-Integrated Ballast LED, 101W, any bulb shape, any application	101W LED - Non-Int. Ballast	Electronic	N/A	N/A	101	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED102-FIXT	LED102W	Non-Integrated Ballast LED, 102W, any bulb shape, any application	102W LED - Non-Int. Ballast	Electronic	N/A	N/A	102	15
LED103-FIXT	LED103W	Non-Integrated Ballast LED, 103W, any bulb shape, any application	103W LED - Non-Int. Ballast	Electronic	N/A	N/A	103	15
LED104-FIXT	LED104W	Non-Integrated Ballast LED, 104W, any bulb shape, any application	104W LED - Non-Int. Ballast	Electronic	N/A	N/A	104	15
LED105-FIXT	LED105W	Non-Integrated Ballast LED, 105W, any bulb shape, any application	105W LED - Non-Int. Ballast	Electronic	N/A	N/A	105	15
LED106-FIXT	LED106W	Non-Integrated Ballast LED, 106W, any bulb shape, any application	106W LED - Non-Int. Ballast	Electronic	N/A	N/A	106	15
LED107-FIXT	LED107W	Non-Integrated Ballast LED, 107W, any bulb shape, any application	107W LED - Non-Int. Ballast	Electronic	N/A	N/A	107	15
LED108-FIXT	LED108W	Non-Integrated Ballast LED, 108W, any bulb shape, any application	108W LED - Non-Int. Ballast	Electronic	N/A	N/A	108	15
LED109-FIXT	LED109W	Non-Integrated Ballast LED, 109W, any bulb shape, any application	109W LED - Non-Int. Ballast	Electronic	N/A	N/A	109	15
LED110-FIXT	LED110W	Non-Integrated Ballast LED, 110W, any bulb shape, any application	110W LED - Non-Int. Ballast	Electronic	N/A	N/A	110	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED111-FIXT	LED111W	Non-Integrated Ballast LED, 111W, any bulb shape, any application	111W LED - Non-Int. Ballast	Electronic	N/A	N/A	111	15
LED112-FIXT	LED112W	Non-Integrated Ballast LED, 112W, any bulb shape, any application	112W LED - Non-Int. Ballast	Electronic	N/A	N/A	112	15
LED113-FIXT	LED113W	Non-Integrated Ballast LED, 113W, any bulb shape, any application	113W LED - Non-Int. Ballast	Electronic	N/A	N/A	113	15
LED114-FIXT	LED114W	Non-Integrated Ballast LED, 114W, any bulb shape, any application	114W LED - Non-Int. Ballast	Electronic	N/A	N/A	114	15
LED115-FIXT	LED115W	Non-Integrated Ballast LED, 115W, any bulb shape, any application	115W LED - Non-Int. Ballast	Electronic	N/A	N/A	115	15
LED116-FIXT	LED116W	Non-Integrated Ballast LED, 116W, any bulb shape, any application	116W LED - Non-Int. Ballast	Electronic	N/A	N/A	116	15
LED117-FIXT	LED117W	Non-Integrated Ballast LED, 117W, any bulb shape, any application	117W LED - Non-Int. Ballast	Electronic	N/A	N/A	117	15
LED118-FIXT	LED118W	Non-Integrated Ballast LED, 118W, any bulb shape, any application	118W LED - Non-Int. Ballast	Electronic	N/A	N/A	118	15
LED119-FIXT	LED119W	Non-Integrated Ballast LED, 119W, any bulb shape, any application	119W LED - Non-Int. Ballast	Electronic	N/A	N/A	119	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED120-FIXT	LED120W	Non-Integrated Ballast LED, 120W, any bulb shape, any application	120W LED - Non-Int. Ballast	Electronic	N/A	N/A	120	15
LED121-FIXT	LED121W	Non-Integrated Ballast LED, 121W, any bulb shape, any application	121W LED - Non-Int. Ballast	Electronic	N/A	N/A	121	15
LED122-FIXT	LED122W	Non-Integrated Ballast LED, 122W, any bulb shape, any application	122W LED - Non-Int. Ballast	Electronic	N/A	N/A	122	15
LED123-FIXT	LED123W	Non-Integrated Ballast LED, 123W, any bulb shape, any application	123W LED - Non-Int. Ballast	Electronic	N/A	N/A	123	15
LED124-FIXT	LED124W	Non-Integrated Ballast LED, 124W, any bulb shape, any application	124W LED - Non-Int. Ballast	Electronic	N/A	N/A	124	15
LED125-FIXT	LED125W	Non-Integrated Ballast LED, 125W, any bulb shape, any application	125W LED - Non-Int. Ballast	Electronic	N/A	N/A	125	15
LED126-FIXT	LED126W	Non-Integrated Ballast LED, 126W, any bulb shape, any application	126W LED - Non-Int. Ballast	Electronic	N/A	N/A	126	15
LED127-FIXT	LED127W	Non-Integrated Ballast LED, 127W, any bulb shape, any application	127W LED - Non-Int. Ballast	Electronic	N/A	N/A	127	15
LED128-FIXT	LED128W	Non-Integrated Ballast LED, 128W, any bulb shape, any application	128W LED - Non-Int. Ballast	Electronic	N/A	N/A	128	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED129-FIXT	LED129W	Non-Integrated Ballast LED, 129W, any bulb shape, any application	129W LED - Non-Int. Ballast	Electronic	N/A	N/A	129	15
LED130-FIXT	LED130W	Non-Integrated Ballast LED, 130W, any bulb shape, any application	130W LED - Non-Int. Ballast	Electronic	N/A	N/A	130	15
LED131-FIXT	LED131W	Non-Integrated Ballast LED, 131W, any bulb shape, any application	131W LED - Non-Int. Ballast	Electronic	N/A	N/A	131	15
LED132-FIXT	LED132W	Non-Integrated Ballast LED, 132W, any bulb shape, any application	132W LED - Non-Int. Ballast	Electronic	N/A	N/A	132	15
LED133-FIXT	LED133W	Non-Integrated Ballast LED, 133W, any bulb shape, any application	133W LED - Non-Int. Ballast	Electronic	N/A	N/A	133	15
LED134-FIXT	LED134W	Non-Integrated Ballast LED, 134W, any bulb shape, any application	134W LED - Non-Int. Ballast	Electronic	N/A	N/A	134	15
LED135-FIXT	LED135W	Non-Integrated Ballast LED, 135W, any bulb shape, any application	135W LED - Non-Int. Ballast	Electronic	N/A	N/A	135	15
LED136-FIXT	LED136W	Non-Integrated Ballast LED, 136W, any bulb shape, any application	136W LED - Non-Int. Ballast	Electronic	N/A	N/A	136	15
LED137-FIXT	LED137W	Non-Integrated Ballast LED, 137W, any bulb shape, any application	137W LED - Non-Int. Ballast	Electronic	N/A	N/A	137	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED138-FIXT	LED138W	Non-Integrated Ballast LED, 138W, any bulb shape, any application	138W LED - Non-Int. Ballast	Electronic	N/A	N/A	138	15
LED139-FIXT	LED139W	Non-Integrated Ballast LED, 139W, any bulb shape, any application	139W LED - Non-Int. Ballast	Electronic	N/A	N/A	139	15
LED140-FIXT	LED140W	Non-Integrated Ballast LED, 140W, any bulb shape, any application	140W LED - Non-Int. Ballast	Electronic	N/A	N/A	140	15
LED141-FIXT	LED141W	Non-Integrated Ballast LED, 141W, any bulb shape, any application	141W LED - Non-Int. Ballast	Electronic	N/A	N/A	141	15
LED142-FIXT	LED142W	Non-Integrated Ballast LED, 142W, any bulb shape, any application	142W LED - Non-Int. Ballast	Electronic	N/A	N/A	142	15
LED143-FIXT	LED143W	Non-Integrated Ballast LED, 143W, any bulb shape, any application	143W LED - Non-Int. Ballast	Electronic	N/A	N/A	143	15
LED144-FIXT	LED144W	Non-Integrated Ballast LED, 144W, any bulb shape, any application	144W LED - Non-Int. Ballast	Electronic	N/A	N/A	144	15
LED145-FIXT	LED145W	Non-Integrated Ballast LED, 145W, any bulb shape, any application	145W LED - Non-Int. Ballast	Electronic	N/A	N/A	145	15
LED146-FIXT	LED146W	Non-Integrated Ballast LED, 146W, any bulb shape, any application	146W LED - Non-Int. Ballast	Electronic	N/A	N/A	146	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED147-FIXT	LED147W	Non-Integrated Ballast LED, 147W, any bulb shape, any application	147W LED - Non-Int. Ballast	Electronic	N/A	N/A	147	15
LED148-FIXT	LED148W	Non-Integrated Ballast LED, 148W, any bulb shape, any application	148W LED - Non-Int. Ballast	Electronic	N/A	N/A	148	15
LED149-FIXT	LED149W	Non-Integrated Ballast LED, 149W, any bulb shape, any application	149W LED - Non-Int. Ballast	Electronic	N/A	N/A	149	15
LED150-FIXT	LED150W	Non-Integrated Ballast LED, 150W, any bulb shape, any application	150W LED - Non-Int. Ballast	Electronic	N/A	N/A	150	15
LED151-FIXT	LED151W	Non-Integrated Ballast LED, 151W, any bulb shape, any application	151W LED - Non-Int. Ballast	Electronic	N/A	N/A	151	15
LED152-FIXT	LED152W	Non-Integrated Ballast LED, 152W, any bulb shape, any application	152W LED - Non-Int. Ballast	Electronic	N/A	N/A	152	15
LED153-FIXT	LED153W	Non-Integrated Ballast LED, 153W, any bulb shape, any application	153W LED - Non-Int. Ballast	Electronic	N/A	N/A	153	15
LED154-FIXT	LED154W	Non-Integrated Ballast LED, 154W, any bulb shape, any application	154W LED - Non-Int. Ballast	Electronic	N/A	N/A	154	15
LED155-FIXT	LED155W	Non-Integrated Ballast LED, 155W, any bulb shape, any application	155W LED - Non-Int. Ballast	Electronic	N/A	N/A	155	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED156-FIXT	LED156W	Non-Integrated Ballast LED, 156W, any bulb shape, any application	156W LED - Non-Int. Ballast	Electronic	N/A	N/A	156	15
LED157-FIXT	LED157W	Non-Integrated Ballast LED, 157W, any bulb shape, any application	157W LED - Non-Int. Ballast	Electronic	N/A	N/A	157	15
LED158-FIXT	LED158W	Non-Integrated Ballast LED, 158W, any bulb shape, any application	158W LED - Non-Int. Ballast	Electronic	N/A	N/A	158	15
LED159-FIXT	LED159W	Non-Integrated Ballast LED, 159W, any bulb shape, any application	159W LED - Non-Int. Ballast	Electronic	N/A	N/A	159	15
LED160-FIXT	LED160W	Non-Integrated Ballast LED, 160W, any bulb shape, any application	160W LED - Non-Int. Ballast	Electronic	N/A	N/A	160	15
LED161-FIXT	LED161W	Non-Integrated Ballast LED, 161W, any bulb shape, any application	161W LED - Non-Int. Ballast	Electronic	N/A	N/A	161	15
LED162-FIXT	LED162W	Non-Integrated Ballast LED, 162W, any bulb shape, any application	162W LED - Non-Int. Ballast	Electronic	N/A	N/A	162	15
LED163-FIXT	LED163W	Non-Integrated Ballast LED, 163W, any bulb shape, any application	163W LED - Non-Int. Ballast	Electronic	N/A	N/A	163	15
LED164-FIXT	LED164W	Non-Integrated Ballast LED, 164W, any bulb shape, any application	164W LED - Non-Int. Ballast	Electronic	N/A	N/A	164	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED165-FIXT	LED165W	Non-Integrated Ballast LED, 165W, any bulb shape, any application	165W LED - Non-Int. Ballast	Electronic	N/A	N/A	165	15
LED166-FIXT	LED166W	Non-Integrated Ballast LED, 166W, any bulb shape, any application	166W LED - Non-Int. Ballast	Electronic	N/A	N/A	166	15
LED167-FIXT	LED167W	Non-Integrated Ballast LED, 167W, any bulb shape, any application	167W LED - Non-Int. Ballast	Electronic	N/A	N/A	167	15
LED168-FIXT	LED168W	Non-Integrated Ballast LED, 168W, any bulb shape, any application	168W LED - Non-Int. Ballast	Electronic	N/A	N/A	168	15
LED169-FIXT	LED169W	Non-Integrated Ballast LED, 169W, any bulb shape, any application	169W LED - Non-Int. Ballast	Electronic	N/A	N/A	169	15
LED170-FIXT	LED170W	Non-Integrated Ballast LED, 170W, any bulb shape, any application	170W LED - Non-Int. Ballast	Electronic	N/A	N/A	170	15
LED171-FIXT	LED171W	Non-Integrated Ballast LED, 171W, any bulb shape, any application	171W LED - Non-Int. Ballast	Electronic	N/A	N/A	171	15
LED172-FIXT	LED172W	Non-Integrated Ballast LED, 172W, any bulb shape, any application	172W LED - Non-Int. Ballast	Electronic	N/A	N/A	172	15
LED173-FIXT	LED173W	Non-Integrated Ballast LED, 173W, any bulb shape, any application	173W LED - Non-Int. Ballast	Electronic	N/A	N/A	173	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED174-FIXT	LED174W	Non-Integrated Ballast LED, 174W, any bulb shape, any application	174W LED - Non-Int. Ballast	Electronic	N/A	N/A	174	15
LED175-FIXT	LED175W	Non-Integrated Ballast LED, 175W, any bulb shape, any application	175W LED - Non-Int. Ballast	Electronic	N/A	N/A	175	15
LED176-FIXT	LED176W	Non-Integrated Ballast LED, 176W, any bulb shape, any application	176W LED - Non-Int. Ballast	Electronic	N/A	N/A	176	15
LED177-FIXT	LED177W	Non-Integrated Ballast LED, 177W, any bulb shape, any application	177W LED - Non-Int. Ballast	Electronic	N/A	N/A	177	15
LED178-FIXT	LED178W	Non-Integrated Ballast LED, 178W, any bulb shape, any application	178W LED - Non-Int. Ballast	Electronic	N/A	N/A	178	15
LED179-FIXT	LED179W	Non-Integrated Ballast LED, 179W, any bulb shape, any application	179W LED - Non-Int. Ballast	Electronic	N/A	N/A	179	15
LED180-FIXT	LED180W	Non-Integrated Ballast LED, 180W, any bulb shape, any application	180W LED - Non-Int. Ballast	Electronic	N/A	N/A	180	15
LED181-FIXT	LED181W	Non-Integrated Ballast LED, 181W, any bulb shape, any application	181W LED - Non-Int. Ballast	Electronic	N/A	N/A	181	15
LED182-FIXT	LED182W	Non-Integrated Ballast LED, 182W, any bulb shape, any application	182W LED - Non-Int. Ballast	Electronic	N/A	N/A	182	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED183-FIXT	LED183W	Non-Integrated Ballast LED, 183W, any bulb shape, any application	183W LED - Non-Int. Ballast	Electronic	N/A	N/A	183	15
LED184-FIXT	LED184W	Non-Integrated Ballast LED, 184W, any bulb shape, any application	184W LED - Non-Int. Ballast	Electronic	N/A	N/A	184	15
LED185-FIXT	LED185W	Non-Integrated Ballast LED, 185W, any bulb shape, any application	185W LED - Non-Int. Ballast	Electronic	N/A	N/A	185	15
LED186-FIXT	LED186W	Non-Integrated Ballast LED, 186W, any bulb shape, any application	186W LED - Non-Int. Ballast	Electronic	N/A	N/A	186	15
LED187-FIXT	LED187W	Non-Integrated Ballast LED, 187W, any bulb shape, any application	187W LED - Non-Int. Ballast	Electronic	N/A	N/A	187	15
LED188-FIXT	LED188W	Non-Integrated Ballast LED, 188W, any bulb shape, any application	188W LED - Non-Int. Ballast	Electronic	N/A	N/A	188	15
LED189-FIXT	LED189W	Non-Integrated Ballast LED, 189W, any bulb shape, any application	189W LED - Non-Int. Ballast	Electronic	N/A	N/A	189	15
LED190-FIXT	LED190W	Non-Integrated Ballast LED, 190W, any bulb shape, any application	190W LED - Non-Int. Ballast	Electronic	N/A	N/A	190	15
LED191-FIXT	LED191W	Non-Integrated Ballast LED, 191W, any bulb shape, any application	191W LED - Non-Int. Ballast	Electronic	N/A	N/A	191	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED192-FIXT	LED192W	Non-Integrated Ballast LED, 192W, any bulb shape, any application	192W LED - Non-Int. Ballast	Electronic	N/A	N/A	192	15
LED193-FIXT	LED193W	Non-Integrated Ballast LED, 193W, any bulb shape, any application	193W LED - Non-Int. Ballast	Electronic	N/A	N/A	193	15
LED194-FIXT	LED194W	Non-Integrated Ballast LED, 194W, any bulb shape, any application	194W LED - Non-Int. Ballast	Electronic	N/A	N/A	194	15
LED195-FIXT	LED195W	Non-Integrated Ballast LED, 195W, any bulb shape, any application	195W LED - Non-Int. Ballast	Electronic	N/A	N/A	195	15
LED196-FIXT	LED196W	Non-Integrated Ballast LED, 196W, any bulb shape, any application	196W LED - Non-Int. Ballast	Electronic	N/A	N/A	196	15
LED197-FIXT	LED197W	Non-Integrated Ballast LED, 197W, any bulb shape, any application	197W LED - Non-Int. Ballast	Electronic	N/A	N/A	197	15
LED198-FIXT	LED198W	Non-Integrated Ballast LED, 198W, any bulb shape, any application	198W LED - Non-Int. Ballast	Electronic	N/A	N/A	198	15
LED199-FIXT	LED199W	Non-Integrated Ballast LED, 199W, any bulb shape, any application	199W LED - Non-Int. Ballast	Electronic	N/A	N/A	199	15
LED200-FIXT	LED200W	Non-Integrated Ballast LED, 200W, any bulb shape, any application	200W LED - Non-Int. Ballast	Electronic	N/A	N/A	200	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED201-FIXT	LED201W	Non-Integrated Ballast LED, 201W, any bulb shape, any application	201W LED - Non-Int. Ballast	Electronic	N/A	N/A	201	15
LED202-FIXT	LED202W	Non-Integrated Ballast LED, 202W, any bulb shape, any application	202W LED - Non-Int. Ballast	Electronic	N/A	N/A	202	15
LED203-FIXT	LED203W	Non-Integrated Ballast LED, 203W, any bulb shape, any application	203W LED - Non-Int. Ballast	Electronic	N/A	N/A	203	15
LED204-FIXT	LED204W	Non-Integrated Ballast LED, 204W, any bulb shape, any application	204W LED - Non-Int. Ballast	Electronic	N/A	N/A	204	15
LED205-FIXT	LED205W	Non-Integrated Ballast LED, 205W, any bulb shape, any application	205W LED - Non-Int. Ballast	Electronic	N/A	N/A	205	15
LED206-FIXT	LED206W	Non-Integrated Ballast LED, 206W, any bulb shape, any application	206W LED - Non-Int. Ballast	Electronic	N/A	N/A	206	15
LED207-FIXT	LED207W	Non-Integrated Ballast LED, 207W, any bulb shape, any application	207W LED - Non-Int. Ballast	Electronic	N/A	N/A	207	15
LED208-FIXT	LED208W	Non-Integrated Ballast LED, 208W, any bulb shape, any application	208W LED - Non-Int. Ballast	Electronic	N/A	N/A	208	15
LED209-FIXT	LED209W	Non-Integrated Ballast LED, 209W, any bulb shape, any application	209W LED - Non-Int. Ballast	Electronic	N/A	N/A	209	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED210-FIXT	LED210W	Non-Integrated Ballast LED, 210W, any bulb shape, any application	210W LED - Non-Int. Ballast	Electronic	N/A	N/A	210	15
LED211-FIXT	LED211W	Non-Integrated Ballast LED, 211W, any bulb shape, any application	211W LED - Non-Int. Ballast	Electronic	N/A	N/A	211	15
LED212-FIXT	LED212W	Non-Integrated Ballast LED, 212W, any bulb shape, any application	212W LED - Non-Int. Ballast	Electronic	N/A	N/A	212	15
LED213-FIXT	LED213W	Non-Integrated Ballast LED, 213W, any bulb shape, any application	213W LED - Non-Int. Ballast	Electronic	N/A	N/A	213	15
LED214-FIXT	LED214W	Non-Integrated Ballast LED, 214W, any bulb shape, any application	214W LED - Non-Int. Ballast	Electronic	N/A	N/A	214	15
LED215-FIXT	LED215W	Non-Integrated Ballast LED, 215W, any bulb shape, any application	215W LED - Non-Int. Ballast	Electronic	N/A	N/A	215	15
LED216-FIXT	LED216W	Non-Integrated Ballast LED, 216W, any bulb shape, any application	216W LED - Non-Int. Ballast	Electronic	N/A	N/A	216	15
LED217-FIXT	LED217W	Non-Integrated Ballast LED, 217W, any bulb shape, any application	217W LED - Non-Int. Ballast	Electronic	N/A	N/A	217	15
LED218-FIXT	LED218W	Non-Integrated Ballast LED, 218W, any bulb shape, any application	218W LED - Non-Int. Ballast	Electronic	N/A	N/A	218	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED219-FIXT	LED219W	Non-Integrated Ballast LED, 219W, any bulb shape, any application	219W LED - Non-Int. Ballast	Electronic	N/A	N/A	219	15
LED220-FIXT	LED220W	Non-Integrated Ballast LED, 220W, any bulb shape, any application	220W LED - Non-Int. Ballast	Electronic	N/A	N/A	220	15
LED221-FIXT	LED221W	Non-Integrated Ballast LED, 221W, any bulb shape, any application	221W LED - Non-Int. Ballast	Electronic	N/A	N/A	221	15
LED222-FIXT	LED222W	Non-Integrated Ballast LED, 222W, any bulb shape, any application	222W LED - Non-Int. Ballast	Electronic	N/A	N/A	222	15
LED223-FIXT	LED223W	Non-Integrated Ballast LED, 223W, any bulb shape, any application	223W LED - Non-Int. Ballast	Electronic	N/A	N/A	223	15
LED224-FIXT	LED224W	Non-Integrated Ballast LED, 224W, any bulb shape, any application	224W LED - Non-Int. Ballast	Electronic	N/A	N/A	224	15
LED225-FIXT	LED225W	Non-Integrated Ballast LED, 225W, any bulb shape, any application	225W LED - Non-Int. Ballast	Electronic	N/A	N/A	225	15
LED226-FIXT	LED226W	Non-Integrated Ballast LED, 226W, any bulb shape, any application	226W LED - Non-Int. Ballast	Electronic	N/A	N/A	226	15
LED227-FIXT	LED227W	Non-Integrated Ballast LED, 227W, any bulb shape, any application	227W LED - Non-Int. Ballast	Electronic	N/A	N/A	227	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED228-FIXT	LED228W	Non-Integrated Ballast LED, 228W, any bulb shape, any application	228W LED - Non-Int. Ballast	Electronic	N/A	N/A	228	15
LED229-FIXT	LED229W	Non-Integrated Ballast LED, 229W, any bulb shape, any application	229W LED - Non-Int. Ballast	Electronic	N/A	N/A	229	15
LED230-FIXT	LED230W	Non-Integrated Ballast LED, 230W, any bulb shape, any application	230W LED - Non-Int. Ballast	Electronic	N/A	N/A	230	15
LED231-FIXT	LED231W	Non-Integrated Ballast LED, 231W, any bulb shape, any application	231W LED - Non-Int. Ballast	Electronic	N/A	N/A	231	15
LED232-FIXT	LED232W	Non-Integrated Ballast LED, 232W, any bulb shape, any application	232W LED - Non-Int. Ballast	Electronic	N/A	N/A	232	15
LED233-FIXT	LED233W	Non-Integrated Ballast LED, 233W, any bulb shape, any application	233W LED - Non-Int. Ballast	Electronic	N/A	N/A	233	15
LED234-FIXT	LED234W	Non-Integrated Ballast LED, 234W, any bulb shape, any application	234W LED - Non-Int. Ballast	Electronic	N/A	N/A	234	15
LED235-FIXT	LED235W	Non-Integrated Ballast LED, 235W, any bulb shape, any application	235W LED - Non-Int. Ballast	Electronic	N/A	N/A	235	15
LED236-FIXT	LED236W	Non-Integrated Ballast LED, 236W, any bulb shape, any application	236W LED - Non-Int. Ballast	Electronic	N/A	N/A	236	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED237-FIXT	LED237W	Non-Integrated Ballast LED, 237W, any bulb shape, any application	237W LED - Non-Int. Ballast	Electronic	N/A	N/A	237	15
LED238-FIXT	LED238W	Non-Integrated Ballast LED, 238W, any bulb shape, any application	238W LED - Non-Int. Ballast	Electronic	N/A	N/A	238	15
LED239-FIXT	LED239W	Non-Integrated Ballast LED, 239W, any bulb shape, any application	239W LED - Non-Int. Ballast	Electronic	N/A	N/A	239	15
LED240-FIXT	LED240W	Non-Integrated Ballast LED, 240W, any bulb shape, any application	240W LED - Non-Int. Ballast	Electronic	N/A	N/A	240	15
LED241-FIXT	LED241W	Non-Integrated Ballast LED, 241W, any bulb shape, any application	241W LED - Non-Int. Ballast	Electronic	N/A	N/A	241	15
LED242-FIXT	LED242W	Non-Integrated Ballast LED, 242W, any bulb shape, any application	242W LED - Non-Int. Ballast	Electronic	N/A	N/A	242	15
LED243-FIXT	LED243W	Non-Integrated Ballast LED, 243W, any bulb shape, any application	243W LED - Non-Int. Ballast	Electronic	N/A	N/A	243	15
LED244-FIXT	LED244W	Non-Integrated Ballast LED, 244W, any bulb shape, any application	244W LED - Non-Int. Ballast	Electronic	N/A	N/A	244	15
LED245-FIXT	LED245W	Non-Integrated Ballast LED, 245W, any bulb shape, any application	245W LED - Non-Int. Ballast	Electronic	N/A	N/A	245	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED246-FIXT	LED246W	Non-Integrated Ballast LED, 246W, any bulb shape, any application	246W LED - Non-Int. Ballast	Electronic	N/A	N/A	246	15
LED247-FIXT	LED247W	Non-Integrated Ballast LED, 247W, any bulb shape, any application	247W LED - Non-Int. Ballast	Electronic	N/A	N/A	247	15
LED248-FIXT	LED248W	Non-Integrated Ballast LED, 248W, any bulb shape, any application	248W LED - Non-Int. Ballast	Electronic	N/A	N/A	248	15
LED249-FIXT	LED249W	Non-Integrated Ballast LED, 249W, any bulb shape, any application	249W LED - Non-Int. Ballast	Electronic	N/A	N/A	249	15
LED250-FIXT	LED250W	Non-Integrated Ballast LED, 250W, any bulb shape, any application	250W LED - Non-Int. Ballast	Electronic	N/A	N/A	250	15
LED251-FIXT	LED251W	Non-Integrated Ballast LED, 251W, any bulb shape, any application	251W LED - Non-Int. Ballast	Electronic	N/A	N/A	251	15
LED252-FIXT	LED252W	Non-Integrated Ballast LED, 252W, any bulb shape, any application	252W LED - Non-Int. Ballast	Electronic	N/A	N/A	252	15
LED253-FIXT	LED253W	Non-Integrated Ballast LED, 253W, any bulb shape, any application	253W LED - Non-Int. Ballast	Electronic	N/A	N/A	253	15
LED254-FIXT	LED254W	Non-Integrated Ballast LED, 254W, any bulb shape, any application	254W LED - Non-Int. Ballast	Electronic	N/A	N/A	254	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED255-FIXT	LED255W	Non-Integrated Ballast LED, 255W, any bulb shape, any application	255W LED - Non-Int. Ballast	Electronic	N/A	N/A	255	15
LED256-FIXT	LED256W	Non-Integrated Ballast LED, 256W, any bulb shape, any application	256W LED - Non-Int. Ballast	Electronic	N/A	N/A	256	15
LED257-FIXT	LED257W	Non-Integrated Ballast LED, 257W, any bulb shape, any application	257W LED - Non-Int. Ballast	Electronic	N/A	N/A	257	15
LED258-FIXT	LED258W	Non-Integrated Ballast LED, 258W, any bulb shape, any application	258W LED - Non-Int. Ballast	Electronic	N/A	N/A	258	15
LED259-FIXT	LED259W	Non-Integrated Ballast LED, 259W, any bulb shape, any application	259W LED - Non-Int. Ballast	Electronic	N/A	N/A	259	15
LED260-FIXT	LED260W	Non-Integrated Ballast LED, 260W, any bulb shape, any application	260W LED - Non-Int. Ballast	Electronic	N/A	N/A	260	15
LED261-FIXT	LED261W	Non-Integrated Ballast LED, 261W, any bulb shape, any application	261W LED - Non-Int. Ballast	Electronic	N/A	N/A	261	15
LED262-FIXT	LED262W	Non-Integrated Ballast LED, 262W, any bulb shape, any application	262W LED - Non-Int. Ballast	Electronic	N/A	N/A	262	15
LED263-FIXT	LED263W	Non-Integrated Ballast LED, 263W, any bulb shape, any application	263W LED - Non-Int. Ballast	Electronic	N/A	N/A	263	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED264-FIXT	LED264W	Non-Integrated Ballast LED, 264W, any bulb shape, any application	264W LED - Non-Int. Ballast	Electronic	N/A	N/A	264	15
LED265-FIXT	LED265W	Non-Integrated Ballast LED, 265W, any bulb shape, any application	265W LED - Non-Int. Ballast	Electronic	N/A	N/A	265	15
LED266-FIXT	LED266W	Non-Integrated Ballast LED, 266W, any bulb shape, any application	266W LED - Non-Int. Ballast	Electronic	N/A	N/A	266	15
LED267-FIXT	LED267W	Non-Integrated Ballast LED, 267W, any bulb shape, any application	267W LED - Non-Int. Ballast	Electronic	N/A	N/A	267	15
LED268-FIXT	LED268W	Non-Integrated Ballast LED, 268W, any bulb shape, any application	268W LED - Non-Int. Ballast	Electronic	N/A	N/A	268	15
LED269-FIXT	LED269W	Non-Integrated Ballast LED, 269W, any bulb shape, any application	269W LED - Non-Int. Ballast	Electronic	N/A	N/A	269	15
LED270-FIXT	LED270W	Non-Integrated Ballast LED, 270W, any bulb shape, any application	270W LED - Non-Int. Ballast	Electronic	N/A	N/A	270	15
LED271-FIXT	LED271W	Non-Integrated Ballast LED, 271W, any bulb shape, any application	271W LED - Non-Int. Ballast	Electronic	N/A	N/A	271	15
LED272-FIXT	LED272W	Non-Integrated Ballast LED, 272W, any bulb shape, any application	272W LED - Non-Int. Ballast	Electronic	N/A	N/A	272	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED273-FIXT	LED273W	Non-Integrated Ballast LED, 273W, any bulb shape, any application	273W LED - Non-Int. Ballast	Electronic	N/A	N/A	273	15
LED274-FIXT	LED274W	Non-Integrated Ballast LED, 274W, any bulb shape, any application	274W LED - Non-Int. Ballast	Electronic	N/A	N/A	274	15
LED275-FIXT	LED275W	Non-Integrated Ballast LED, 275W, any bulb shape, any application	275W LED - Non-Int. Ballast	Electronic	N/A	N/A	275	15
LED276-FIXT	LED276W	Non-Integrated Ballast LED, 276W, any bulb shape, any application	276W LED - Non-Int. Ballast	Electronic	N/A	N/A	276	15
LED277-FIXT	LED277W	Non-Integrated Ballast LED, 277W, any bulb shape, any application	277W LED - Non-Int. Ballast	Electronic	N/A	N/A	277	15
LED278-FIXT	LED278W	Non-Integrated Ballast LED, 278W, any bulb shape, any application	278W LED - Non-Int. Ballast	Electronic	N/A	N/A	278	15
LED279-FIXT	LED279W	Non-Integrated Ballast LED, 279W, any bulb shape, any application	279W LED - Non-Int. Ballast	Electronic	N/A	N/A	279	15
LED280-FIXT	LED280W	Non-Integrated Ballast LED, 280W, any bulb shape, any application	280W LED - Non-Int. Ballast	Electronic	N/A	N/A	280	15
LED281-FIXT	LED281W	Non-Integrated Ballast LED, 281W, any bulb shape, any application	281W LED - Non-Int. Ballast	Electronic	N/A	N/A	281	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED282-FIXT	LED282W	Non-Integrated Ballast LED, 282W, any bulb shape, any application	282W LED - Non-Int. Ballast	Electronic	N/A	N/A	282	15
LED283-FIXT	LED283W	Non-Integrated Ballast LED, 283W, any bulb shape, any application	283W LED - Non-Int. Ballast	Electronic	N/A	N/A	283	15
LED284-FIXT	LED284W	Non-Integrated Ballast LED, 284W, any bulb shape, any application	284W LED - Non-Int. Ballast	Electronic	N/A	N/A	284	15
LED285-FIXT	LED285W	Non-Integrated Ballast LED, 285W, any bulb shape, any application	285W LED - Non-Int. Ballast	Electronic	N/A	N/A	285	15
LED286-FIXT	LED286W	Non-Integrated Ballast LED, 286W, any bulb shape, any application	286W LED - Non-Int. Ballast	Electronic	N/A	N/A	286	15
LED287-FIXT	LED287W	Non-Integrated Ballast LED, 287W, any bulb shape, any application	287W LED - Non-Int. Ballast	Electronic	N/A	N/A	287	15
LED288-FIXT	LED288W	Non-Integrated Ballast LED, 288W, any bulb shape, any application	288W LED - Non-Int. Ballast	Electronic	N/A	N/A	288	15
LED289-FIXT	LED289W	Non-Integrated Ballast LED, 289W, any bulb shape, any application	289W LED - Non-Int. Ballast	Electronic	N/A	N/A	289	15
LED290-FIXT	LED290W	Non-Integrated Ballast LED, 290W, any bulb shape, any application	290W LED - Non-Int. Ballast	Electronic	N/A	N/A	290	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED291-FIXT	LED291W	Non-Integrated Ballast LED, 291W, any bulb shape, any application	291W LED - Non-Int. Ballast	Electronic	N/A	N/A	291	15
LED292-FIXT	LED292W	Non-Integrated Ballast LED, 292W, any bulb shape, any application	292W LED - Non-Int. Ballast	Electronic	N/A	N/A	292	15
LED293-FIXT	LED293W	Non-Integrated Ballast LED, 293W, any bulb shape, any application	293W LED - Non-Int. Ballast	Electronic	N/A	N/A	293	15
LED294-FIXT	LED294W	Non-Integrated Ballast LED, 294W, any bulb shape, any application	294W LED - Non-Int. Ballast	Electronic	N/A	N/A	294	15
LED295-FIXT	LED295W	Non-Integrated Ballast LED, 295W, any bulb shape, any application	295W LED - Non-Int. Ballast	Electronic	N/A	N/A	295	15
LED296-FIXT	LED296W	Non-Integrated Ballast LED, 296W, any bulb shape, any application	296W LED - Non-Int. Ballast	Electronic	N/A	N/A	296	15
LED297-FIXT	LED297W	Non-Integrated Ballast LED, 297W, any bulb shape, any application	297W LED - Non-Int. Ballast	Electronic	N/A	N/A	297	15
LED298-FIXT	LED298W	Non-Integrated Ballast LED, 298W, any bulb shape, any application	298W LED - Non-Int. Ballast	Electronic	N/A	N/A	298	15
LED299-FIXT	LED299W	Non-Integrated Ballast LED, 299W, any bulb shape, any application	299W LED - Non-Int. Ballast	Electronic	N/A	N/A	299	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED300-FIXT	LED300W	Non-Integrated Ballast LED, 300W, any bulb shape, any application	300W LED - Non-Int. Ballast	Electronic	N/A	N/A	300	15
LED301-FIXT	LED301W	Non-Integrated Ballast LED, 301W, any bulb shape, any application	301W LED - Non-Int. Ballast	Electronic	N/A	N/A	301	15
LED302-FIXT	LED302W	Non-Integrated Ballast LED, 302W, any bulb shape, any application	302W LED - Non-Int. Ballast	Electronic	N/A	N/A	302	15
LED303-FIXT	LED303W	Non-Integrated Ballast LED, 303W, any bulb shape, any application	303W LED - Non-Int. Ballast	Electronic	N/A	N/A	303	15
LED304-FIXT	LED304W	Non-Integrated Ballast LED, 304W, any bulb shape, any application	304W LED - Non-Int. Ballast	Electronic	N/A	N/A	304	15
LED305-FIXT	LED305W	Non-Integrated Ballast LED, 305W, any bulb shape, any application	305W LED - Non-Int. Ballast	Electronic	N/A	N/A	305	15
LED306-FIXT	LED306W	Non-Integrated Ballast LED, 306W, any bulb shape, any application	306W LED - Non-Int. Ballast	Electronic	N/A	N/A	306	15
LED307-FIXT	LED307W	Non-Integrated Ballast LED, 307W, any bulb shape, any application	307W LED - Non-Int. Ballast	Electronic	N/A	N/A	307	15
LED308-FIXT	LED308W	Non-Integrated Ballast LED, 308W, any bulb shape, any application	308W LED - Non-Int. Ballast	Electronic	N/A	N/A	308	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED309-FIXT	LED309W	Non-Integrated Ballast LED, 309W, any bulb shape, any application	309W LED - Non-Int. Ballast	Electronic	N/A	N/A	309	15
LED310-FIXT	LED310W	Non-Integrated Ballast LED, 310W, any bulb shape, any application	310W LED - Non-Int. Ballast	Electronic	N/A	N/A	310	15
LED311-FIXT	LED311W	Non-Integrated Ballast LED, 311W, any bulb shape, any application	311W LED - Non-Int. Ballast	Electronic	N/A	N/A	311	15
LED312-FIXT	LED312W	Non-Integrated Ballast LED, 312W, any bulb shape, any application	312W LED - Non-Int. Ballast	Electronic	N/A	N/A	312	15
LED313-FIXT	LED313W	Non-Integrated Ballast LED, 313W, any bulb shape, any application	313W LED - Non-Int. Ballast	Electronic	N/A	N/A	313	15
LED314-FIXT	LED314W	Non-Integrated Ballast LED, 314W, any bulb shape, any application	314W LED - Non-Int. Ballast	Electronic	N/A	N/A	314	15
LED315-FIXT	LED315W	Non-Integrated Ballast LED, 315W, any bulb shape, any application	315W LED - Non-Int. Ballast	Electronic	N/A	N/A	315	15
LED316-FIXT	LED316W	Non-Integrated Ballast LED, 316W, any bulb shape, any application	316W LED - Non-Int. Ballast	Electronic	N/A	N/A	316	15
LED317-FIXT	LED317W	Non-Integrated Ballast LED, 317W, any bulb shape, any application	317W LED - Non-Int. Ballast	Electronic	N/A	N/A	317	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED318-FIXT	LED318W	Non-Integrated Ballast LED, 318W, any bulb shape, any application	318W LED - Non-Int. Ballast	Electronic	N/A	N/A	318	15
LED319-FIXT	LED319W	Non-Integrated Ballast LED, 319W, any bulb shape, any application	319W LED - Non-Int. Ballast	Electronic	N/A	N/A	319	15
LED320-FIXT	LED320W	Non-Integrated Ballast LED, 320W, any bulb shape, any application	320W LED - Non-Int. Ballast	Electronic	N/A	N/A	320	15
LED321-FIXT	LED321W	Non-Integrated Ballast LED, 321W, any bulb shape, any application	321W LED - Non-Int. Ballast	Electronic	N/A	N/A	321	15
LED322-FIXT	LED322W	Non-Integrated Ballast LED, 322W, any bulb shape, any application	322W LED - Non-Int. Ballast	Electronic	N/A	N/A	322	15
LED323-FIXT	LED323W	Non-Integrated Ballast LED, 323W, any bulb shape, any application	323W LED - Non-Int. Ballast	Electronic	N/A	N/A	323	15
LED324-FIXT	LED324W	Non-Integrated Ballast LED, 324W, any bulb shape, any application	324W LED - Non-Int. Ballast	Electronic	N/A	N/A	324	15
LED325-FIXT	LED325W	Non-Integrated Ballast LED, 325W, any bulb shape, any application	325W LED - Non-Int. Ballast	Electronic	N/A	N/A	325	15
LED326-FIXT	LED326W	Non-Integrated Ballast LED, 326W, any bulb shape, any application	326W LED - Non-Int. Ballast	Electronic	N/A	N/A	326	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED327-FIXT	LED327W	Non-Integrated Ballast LED, 327W, any bulb shape, any application	327W LED - Non-Int. Ballast	Electronic	N/A	N/A	327	15
LED328-FIXT	LED328W	Non-Integrated Ballast LED, 328W, any bulb shape, any application	328W LED - Non-Int. Ballast	Electronic	N/A	N/A	328	15
LED329-FIXT	LED329W	Non-Integrated Ballast LED, 329W, any bulb shape, any application	329W LED - Non-Int. Ballast	Electronic	N/A	N/A	329	15
LED330-FIXT	LED330W	Non-Integrated Ballast LED, 330W, any bulb shape, any application	330W LED - Non-Int. Ballast	Electronic	N/A	N/A	330	15
LED331-FIXT	LED331W	Non-Integrated Ballast LED, 331W, any bulb shape, any application	331W LED - Non-Int. Ballast	Electronic	N/A	N/A	331	15
LED332-FIXT	LED332W	Non-Integrated Ballast LED, 332W, any bulb shape, any application	332W LED - Non-Int. Ballast	Electronic	N/A	N/A	332	15
LED333-FIXT	LED333W	Non-Integrated Ballast LED, 333W, any bulb shape, any application	333W LED - Non-Int. Ballast	Electronic	N/A	N/A	333	15
LED334-FIXT	LED334W	Non-Integrated Ballast LED, 334W, any bulb shape, any application	334W LED - Non-Int. Ballast	Electronic	N/A	N/A	334	15
LED335-FIXT	LED335W	Non-Integrated Ballast LED, 335W, any bulb shape, any application	335W LED - Non-Int. Ballast	Electronic	N/A	N/A	335	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED336-FIXT	LED336W	Non-Integrated Ballast LED, 336W, any bulb shape, any application	336W LED - Non-Int. Ballast	Electronic	N/A	N/A	336	15
LED337-FIXT	LED337W	Non-Integrated Ballast LED, 337W, any bulb shape, any application	337W LED - Non-Int. Ballast	Electronic	N/A	N/A	337	15
LED338-FIXT	LED338W	Non-Integrated Ballast LED, 338W, any bulb shape, any application	338W LED - Non-Int. Ballast	Electronic	N/A	N/A	338	15
LED339-FIXT	LED339W	Non-Integrated Ballast LED, 339W, any bulb shape, any application	339W LED - Non-Int. Ballast	Electronic	N/A	N/A	339	15
LED340-FIXT	LED340W	Non-Integrated Ballast LED, 340W, any bulb shape, any application	340W LED - Non-Int. Ballast	Electronic	N/A	N/A	340	15
LED341-FIXT	LED341W	Non-Integrated Ballast LED, 341W, any bulb shape, any application	341W LED - Non-Int. Ballast	Electronic	N/A	N/A	341	15
LED342-FIXT	LED342W	Non-Integrated Ballast LED, 342W, any bulb shape, any application	342W LED - Non-Int. Ballast	Electronic	N/A	N/A	342	15
LED343-FIXT	LED343W	Non-Integrated Ballast LED, 343W, any bulb shape, any application	343W LED - Non-Int. Ballast	Electronic	N/A	N/A	343	15
LED344-FIXT	LED344W	Non-Integrated Ballast LED, 344W, any bulb shape, any application	344W LED - Non-Int. Ballast	Electronic	N/A	N/A	344	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED345-FIXT	LED345W	Non-Integrated Ballast LED, 345W, any bulb shape, any application	345W LED - Non-Int. Ballast	Electronic	N/A	N/A	345	15
LED346-FIXT	LED346W	Non-Integrated Ballast LED, 346W, any bulb shape, any application	346W LED - Non-Int. Ballast	Electronic	N/A	N/A	346	15
LED347-FIXT	LED347W	Non-Integrated Ballast LED, 347W, any bulb shape, any application	347W LED - Non-Int. Ballast	Electronic	N/A	N/A	347	15
LED348-FIXT	LED348W	Non-Integrated Ballast LED, 348W, any bulb shape, any application	348W LED - Non-Int. Ballast	Electronic	N/A	N/A	348	15
LED349-FIXT	LED349W	Non-Integrated Ballast LED, 349W, any bulb shape, any application	349W LED - Non-Int. Ballast	Electronic	N/A	N/A	349	15
LED350-FIXT	LED350W	Non-Integrated Ballast LED, 350W, any bulb shape, any application	350W LED - Non-Int. Ballast	Electronic	N/A	N/A	350	15
LED351-FIXT	LED351W	Non-Integrated Ballast LED, 351W, any bulb shape, any application	351W LED - Non-Int. Ballast	Electronic	N/A	N/A	351	15
LED352-FIXT	LED352W	Non-Integrated Ballast LED, 352W, any bulb shape, any application	352W LED - Non-Int. Ballast	Electronic	N/A	N/A	352	15
LED353-FIXT	LED353W	Non-Integrated Ballast LED, 353W, any bulb shape, any application	353W LED - Non-Int. Ballast	Electronic	N/A	N/A	353	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED354-FIXT	LED354W	Non-Integrated Ballast LED, 354W, any bulb shape, any application	354W LED - Non-Int. Ballast	Electronic	N/A	N/A	354	15
LED355-FIXT	LED355W	Non-Integrated Ballast LED, 355W, any bulb shape, any application	355W LED - Non-Int. Ballast	Electronic	N/A	N/A	355	15
LED356-FIXT	LED356W	Non-Integrated Ballast LED, 356W, any bulb shape, any application	356W LED - Non-Int. Ballast	Electronic	N/A	N/A	356	15
LED357-FIXT	LED357W	Non-Integrated Ballast LED, 357W, any bulb shape, any application	357W LED - Non-Int. Ballast	Electronic	N/A	N/A	357	15
LED358-FIXT	LED358W	Non-Integrated Ballast LED, 358W, any bulb shape, any application	358W LED - Non-Int. Ballast	Electronic	N/A	N/A	358	15
LED359-FIXT	LED359W	Non-Integrated Ballast LED, 359W, any bulb shape, any application	359W LED - Non-Int. Ballast	Electronic	N/A	N/A	359	15
LED360-FIXT	LED360W	Non-Integrated Ballast LED, 360W, any bulb shape, any application	360W LED - Non-Int. Ballast	Electronic	N/A	N/A	360	15
LED361-FIXT	LED361W	Non-Integrated Ballast LED, 361W, any bulb shape, any application	361W LED - Non-Int. Ballast	Electronic	N/A	N/A	361	15
LED362-FIXT	LED362W	Non-Integrated Ballast LED, 362W, any bulb shape, any application	362W LED - Non-Int. Ballast	Electronic	N/A	N/A	362	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED363-FIXT	LED363W	Non-Integrated Ballast LED, 363W, any bulb shape, any application	363W LED - Non-Int. Ballast	Electronic	N/A	N/A	363	15
LED364-FIXT	LED364W	Non-Integrated Ballast LED, 364W, any bulb shape, any application	364W LED - Non-Int. Ballast	Electronic	N/A	N/A	364	15
LED365-FIXT	LED365W	Non-Integrated Ballast LED, 365W, any bulb shape, any application	365W LED - Non-Int. Ballast	Electronic	N/A	N/A	365	15
LED366-FIXT	LED366W	Non-Integrated Ballast LED, 366W, any bulb shape, any application	366W LED - Non-Int. Ballast	Electronic	N/A	N/A	366	15
LED367-FIXT	LED367W	Non-Integrated Ballast LED, 367W, any bulb shape, any application	367W LED - Non-Int. Ballast	Electronic	N/A	N/A	367	15
LED368-FIXT	LED368W	Non-Integrated Ballast LED, 368W, any bulb shape, any application	368W LED - Non-Int. Ballast	Electronic	N/A	N/A	368	15
LED369-FIXT	LED369W	Non-Integrated Ballast LED, 369W, any bulb shape, any application	369W LED - Non-Int. Ballast	Electronic	N/A	N/A	369	15
LED370-FIXT	LED370W	Non-Integrated Ballast LED, 370W, any bulb shape, any application	370W LED - Non-Int. Ballast	Electronic	N/A	N/A	370	15
LED371-FIXT	LED371W	Non-Integrated Ballast LED, 371W, any bulb shape, any application	371W LED - Non-Int. Ballast	Electronic	N/A	N/A	371	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED372-FIXT	LED372W	Non-Integrated Ballast LED, 372W, any bulb shape, any application	372W LED - Non-Int. Ballast	Electronic	N/A	N/A	372	15
LED373-FIXT	LED373W	Non-Integrated Ballast LED, 373W, any bulb shape, any application	373W LED - Non-Int. Ballast	Electronic	N/A	N/A	373	15
LED374-FIXT	LED374W	Non-Integrated Ballast LED, 374W, any bulb shape, any application	374W LED - Non-Int. Ballast	Electronic	N/A	N/A	374	15
LED375-FIXT	LED375W	Non-Integrated Ballast LED, 375W, any bulb shape, any application	375W LED - Non-Int. Ballast	Electronic	N/A	N/A	375	15
LED376-FIXT	LED376W	Non-Integrated Ballast LED, 376W, any bulb shape, any application	376W LED - Non-Int. Ballast	Electronic	N/A	N/A	376	15
LED377-FIXT	LED377W	Non-Integrated Ballast LED, 377W, any bulb shape, any application	377W LED - Non-Int. Ballast	Electronic	N/A	N/A	377	15
LED378-FIXT	LED378W	Non-Integrated Ballast LED, 378W, any bulb shape, any application	378W LED - Non-Int. Ballast	Electronic	N/A	N/A	378	15
LED379-FIXT	LED379W	Non-Integrated Ballast LED, 379W, any bulb shape, any application	379W LED - Non-Int. Ballast	Electronic	N/A	N/A	379	15
LED380-FIXT	LED380W	Non-Integrated Ballast LED, 380W, any bulb shape, any application	380W LED - Non-Int. Ballast	Electronic	N/A	N/A	380	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED381-FIXT	LED381W	Non-Integrated Ballast LED, 381W, any bulb shape, any application	381W LED - Non-Int. Ballast	Electronic	N/A	N/A	381	15
LED382-FIXT	LED382W	Non-Integrated Ballast LED, 382W, any bulb shape, any application	382W LED - Non-Int. Ballast	Electronic	N/A	N/A	382	15
LED383-FIXT	LED383W	Non-Integrated Ballast LED, 383W, any bulb shape, any application	383W LED - Non-Int. Ballast	Electronic	N/A	N/A	383	15
LED384-FIXT	LED384W	Non-Integrated Ballast LED, 384W, any bulb shape, any application	384W LED - Non-Int. Ballast	Electronic	N/A	N/A	384	15
LED385-FIXT	LED385W	Non-Integrated Ballast LED, 385W, any bulb shape, any application	385W LED - Non-Int. Ballast	Electronic	N/A	N/A	385	15
LED386-FIXT	LED386W	Non-Integrated Ballast LED, 386W, any bulb shape, any application	386W LED - Non-Int. Ballast	Electronic	N/A	N/A	386	15
LED387-FIXT	LED387W	Non-Integrated Ballast LED, 387W, any bulb shape, any application	387W LED - Non-Int. Ballast	Electronic	N/A	N/A	387	15
LED388-FIXT	LED388W	Non-Integrated Ballast LED, 388W, any bulb shape, any application	388W LED - Non-Int. Ballast	Electronic	N/A	N/A	388	15
LED389-FIXT	LED389W	Non-Integrated Ballast LED, 389W, any bulb shape, any application	389W LED - Non-Int. Ballast	Electronic	N/A	N/A	389	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED390-FIXT	LED390W	Non-Integrated Ballast LED, 390W, any bulb shape, any application	390W LED - Non-Int. Ballast	Electronic	N/A	N/A	390	15
LED391-FIXT	LED391W	Non-Integrated Ballast LED, 391W, any bulb shape, any application	391W LED - Non-Int. Ballast	Electronic	N/A	N/A	391	15
LED392-FIXT	LED392W	Non-Integrated Ballast LED, 392W, any bulb shape, any application	392W LED - Non-Int. Ballast	Electronic	N/A	N/A	392	15
LED393-FIXT	LED393W	Non-Integrated Ballast LED, 393W, any bulb shape, any application	393W LED - Non-Int. Ballast	Electronic	N/A	N/A	393	15
LED394-FIXT	LED394W	Non-Integrated Ballast LED, 394W, any bulb shape, any application	394W LED - Non-Int. Ballast	Electronic	N/A	N/A	394	15
LED395-FIXT	LED395W	Non-Integrated Ballast LED, 395W, any bulb shape, any application	395W LED - Non-Int. Ballast	Electronic	N/A	N/A	395	15
LED396-FIXT	LED396W	Non-Integrated Ballast LED, 396W, any bulb shape, any application	396W LED - Non-Int. Ballast	Electronic	N/A	N/A	396	15
LED397-FIXT	LED397W	Non-Integrated Ballast LED, 397W, any bulb shape, any application	397W LED - Non-Int. Ballast	Electronic	N/A	N/A	397	15
LED398-FIXT	LED398W	Non-Integrated Ballast LED, 398W, any bulb shape, any application	398W LED - Non-Int. Ballast	Electronic	N/A	N/A	398	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED399-FIXT	LED399W	Non-Integrated Ballast LED, 399W, any bulb shape, any application	399W LED - Non-Int. Ballast	Electronic	N/A	N/A	399	15
LED400-FIXT	LED400W	Non-Integrated Ballast LED, 400W, any bulb shape, any application	400W LED - Non-Int. Ballast	Electronic	N/A	N/A	400	15
LED401-FIXT	LED401W	Non-Integrated Ballast LED, 401W, any bulb shape, any application	401W LED - Non-Int. Ballast	Electronic	N/A	N/A	401	15
LED402-FIXT	LED402W	Non-Integrated Ballast LED, 402W, any bulb shape, any application	402W LED - Non-Int. Ballast	Electronic	N/A	N/A	402	15
LED403-FIXT	LED403W	Non-Integrated Ballast LED, 403W, any bulb shape, any application	403W LED - Non-Int. Ballast	Electronic	N/A	N/A	403	15
LED404-FIXT	LED404W	Non-Integrated Ballast LED, 404W, any bulb shape, any application	404W LED - Non-Int. Ballast	Electronic	N/A	N/A	404	15
LED405-FIXT	LED405W	Non-Integrated Ballast LED, 405W, any bulb shape, any application	405W LED - Non-Int. Ballast	Electronic	N/A	N/A	405	15
LED406-FIXT	LED406W	Non-Integrated Ballast LED, 406W, any bulb shape, any application	406W LED - Non-Int. Ballast	Electronic	N/A	N/A	406	15
LED407-FIXT	LED407W	Non-Integrated Ballast LED, 407W, any bulb shape, any application	407W LED - Non-Int. Ballast	Electronic	N/A	N/A	407	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED408-FIXT	LED408W	Non-Integrated Ballast LED, 408W, any bulb shape, any application	408W LED - Non-Int. Ballast	Electronic	N/A	N/A	408	15
LED409-FIXT	LED409W	Non-Integrated Ballast LED, 409W, any bulb shape, any application	409W LED - Non-Int. Ballast	Electronic	N/A	N/A	409	15
LED410-FIXT	LED410W	Non-Integrated Ballast LED, 410W, any bulb shape, any application	410W LED - Non-Int. Ballast	Electronic	N/A	N/A	410	15
LED411-FIXT	LED411W	Non-Integrated Ballast LED, 411W, any bulb shape, any application	411W LED - Non-Int. Ballast	Electronic	N/A	N/A	411	15
LED412-FIXT	LED412W	Non-Integrated Ballast LED, 412W, any bulb shape, any application	412W LED - Non-Int. Ballast	Electronic	N/A	N/A	412	15
LED413-FIXT	LED413W	Non-Integrated Ballast LED, 413W, any bulb shape, any application	413W LED - Non-Int. Ballast	Electronic	N/A	N/A	413	15
LED414-FIXT	LED414W	Non-Integrated Ballast LED, 414W, any bulb shape, any application	414W LED - Non-Int. Ballast	Electronic	N/A	N/A	414	15
LED415-FIXT	LED415W	Non-Integrated Ballast LED, 415W, any bulb shape, any application	415W LED - Non-Int. Ballast	Electronic	N/A	N/A	415	15
LED416-FIXT	LED416W	Non-Integrated Ballast LED, 416W, any bulb shape, any application	416W LED - Non-Int. Ballast	Electronic	N/A	N/A	416	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED417-FIXT	LED417W	Non-Integrated Ballast LED, 417W, any bulb shape, any application	417W LED - Non-Int. Ballast	Electronic	N/A	N/A	417	15
LED418-FIXT	LED418W	Non-Integrated Ballast LED, 418W, any bulb shape, any application	418W LED - Non-Int. Ballast	Electronic	N/A	N/A	418	15
LED419-FIXT	LED419W	Non-Integrated Ballast LED, 419W, any bulb shape, any application	419W LED - Non-Int. Ballast	Electronic	N/A	N/A	419	15
LED420-FIXT	LED420W	Non-Integrated Ballast LED, 420W, any bulb shape, any application	420W LED - Non-Int. Ballast	Electronic	N/A	N/A	420	15
LED421-FIXT	LED421W	Non-Integrated Ballast LED, 421W, any bulb shape, any application	421W LED - Non-Int. Ballast	Electronic	N/A	N/A	421	15
LED422-FIXT	LED422W	Non-Integrated Ballast LED, 422W, any bulb shape, any application	422W LED - Non-Int. Ballast	Electronic	N/A	N/A	422	15
LED423-FIXT	LED423W	Non-Integrated Ballast LED, 423W, any bulb shape, any application	423W LED - Non-Int. Ballast	Electronic	N/A	N/A	423	15
LED424-FIXT	LED424W	Non-Integrated Ballast LED, 424W, any bulb shape, any application	424W LED - Non-Int. Ballast	Electronic	N/A	N/A	424	15
LED425-FIXT	LED425W	Non-Integrated Ballast LED, 425W, any bulb shape, any application	425W LED - Non-Int. Ballast	Electronic	N/A	N/A	425	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED426-FIXT	LED426W	Non-Integrated Ballast LED, 426W, any bulb shape, any application	426W LED - Non-Int. Ballast	Electronic	N/A	N/A	426	15
LED427-FIXT	LED427W	Non-Integrated Ballast LED, 427W, any bulb shape, any application	427W LED - Non-Int. Ballast	Electronic	N/A	N/A	427	15
LED428-FIXT	LED428W	Non-Integrated Ballast LED, 428W, any bulb shape, any application	428W LED - Non-Int. Ballast	Electronic	N/A	N/A	428	15
LED429-FIXT	LED429W	Non-Integrated Ballast LED, 429W, any bulb shape, any application	429W LED - Non-Int. Ballast	Electronic	N/A	N/A	429	15
LED430-FIXT	LED430W	Non-Integrated Ballast LED, 430W, any bulb shape, any application	430W LED - Non-Int. Ballast	Electronic	N/A	N/A	430	15
LED431-FIXT	LED431W	Non-Integrated Ballast LED, 431W, any bulb shape, any application	431W LED - Non-Int. Ballast	Electronic	N/A	N/A	431	15
LED432-FIXT	LED432W	Non-Integrated Ballast LED, 432W, any bulb shape, any application	432W LED - Non-Int. Ballast	Electronic	N/A	N/A	432	15
LED433-FIXT	LED433W	Non-Integrated Ballast LED, 433W, any bulb shape, any application	433W LED - Non-Int. Ballast	Electronic	N/A	N/A	433	15
LED434-FIXT	LED434W	Non-Integrated Ballast LED, 434W, any bulb shape, any application	434W LED - Non-Int. Ballast	Electronic	N/A	N/A	434	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED435-FIXT	LED435W	Non-Integrated Ballast LED, 435W, any bulb shape, any application	435W LED - Non-Int. Ballast	Electronic	N/A	N/A	435	15
LED436-FIXT	LED436W	Non-Integrated Ballast LED, 436W, any bulb shape, any application	436W LED - Non-Int. Ballast	Electronic	N/A	N/A	436	15
LED437-FIXT	LED437W	Non-Integrated Ballast LED, 437W, any bulb shape, any application	437W LED - Non-Int. Ballast	Electronic	N/A	N/A	437	15
LED438-FIXT	LED438W	Non-Integrated Ballast LED, 438W, any bulb shape, any application	438W LED - Non-Int. Ballast	Electronic	N/A	N/A	438	15
LED439-FIXT	LED439W	Non-Integrated Ballast LED, 439W, any bulb shape, any application	439W LED - Non-Int. Ballast	Electronic	N/A	N/A	439	15
LED440-FIXT	LED440W	Non-Integrated Ballast LED, 440W, any bulb shape, any application	440W LED - Non-Int. Ballast	Electronic	N/A	N/A	440	15
LED441-FIXT	LED441W	Non-Integrated Ballast LED, 441W, any bulb shape, any application	441W LED - Non-Int. Ballast	Electronic	N/A	N/A	441	15
LED442-FIXT	LED442W	Non-Integrated Ballast LED, 442W, any bulb shape, any application	442W LED - Non-Int. Ballast	Electronic	N/A	N/A	442	15
LED443-FIXT	LED443W	Non-Integrated Ballast LED, 443W, any bulb shape, any application	443W LED - Non-Int. Ballast	Electronic	N/A	N/A	443	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED444-FIXT	LED444W	Non-Integrated Ballast LED, 444W, any bulb shape, any application	444W LED - Non-Int. Ballast	Electronic	N/A	N/A	444	15
LED445-FIXT	LED445W	Non-Integrated Ballast LED, 445W, any bulb shape, any application	445W LED - Non-Int. Ballast	Electronic	N/A	N/A	445	15
LED446-FIXT	LED446W	Non-Integrated Ballast LED, 446W, any bulb shape, any application	446W LED - Non-Int. Ballast	Electronic	N/A	N/A	446	15
LED447-FIXT	LED447W	Non-Integrated Ballast LED, 447W, any bulb shape, any application	447W LED - Non-Int. Ballast	Electronic	N/A	N/A	447	15
LED448-FIXT	LED448W	Non-Integrated Ballast LED, 448W, any bulb shape, any application	448W LED - Non-Int. Ballast	Electronic	N/A	N/A	448	15
LED449-FIXT	LED449W	Non-Integrated Ballast LED, 449W, any bulb shape, any application	449W LED - Non-Int. Ballast	Electronic	N/A	N/A	449	15
LED450-FIXT	LED450W	Non-Integrated Ballast LED, 450W, any bulb shape, any application	450W LED - Non-Int. Ballast	Electronic	N/A	N/A	450	15
LED451-FIXT	LED451W	Non-Integrated Ballast LED, 451W, any bulb shape, any application	451W LED - Non-Int. Ballast	Electronic	N/A	N/A	451	15
LED452-FIXT	LED452W	Non-Integrated Ballast LED, 452W, any bulb shape, any application	452W LED - Non-Int. Ballast	Electronic	N/A	N/A	452	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED453-FIXT	LED453W	Non-Integrated Ballast LED, 453W, any bulb shape, any application	453W LED - Non-Int. Ballast	Electronic	N/A	N/A	453	15
LED454-FIXT	LED454W	Non-Integrated Ballast LED, 454W, any bulb shape, any application	454W LED - Non-Int. Ballast	Electronic	N/A	N/A	454	15
LED455-FIXT	LED455W	Non-Integrated Ballast LED, 455W, any bulb shape, any application	455W LED - Non-Int. Ballast	Electronic	N/A	N/A	455	15
LED456-FIXT	LED456W	Non-Integrated Ballast LED, 456W, any bulb shape, any application	456W LED - Non-Int. Ballast	Electronic	N/A	N/A	456	15
LED457-FIXT	LED457W	Non-Integrated Ballast LED, 457W, any bulb shape, any application	457W LED - Non-Int. Ballast	Electronic	N/A	N/A	457	15
LED458-FIXT	LED458W	Non-Integrated Ballast LED, 458W, any bulb shape, any application	458W LED - Non-Int. Ballast	Electronic	N/A	N/A	458	15
LED459-FIXT	LED459W	Non-Integrated Ballast LED, 459W, any bulb shape, any application	459W LED - Non-Int. Ballast	Electronic	N/A	N/A	459	15
LED460-FIXT	LED460W	Non-Integrated Ballast LED, 460W, any bulb shape, any application	460W LED - Non-Int. Ballast	Electronic	N/A	N/A	460	15
LED461-FIXT	LED461W	Non-Integrated Ballast LED, 461W, any bulb shape, any application	461W LED - Non-Int. Ballast	Electronic	N/A	N/A	461	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED462-FIXT	LED462W	Non-Integrated Ballast LED, 462W, any bulb shape, any application	462W LED - Non-Int. Ballast	Electronic	N/A	N/A	462	15
LED463-FIXT	LED463W	Non-Integrated Ballast LED, 463W, any bulb shape, any application	463W LED - Non-Int. Ballast	Electronic	N/A	N/A	463	15
LED464-FIXT	LED464W	Non-Integrated Ballast LED, 464W, any bulb shape, any application	464W LED - Non-Int. Ballast	Electronic	N/A	N/A	464	15
LED465-FIXT	LED465W	Non-Integrated Ballast LED, 465W, any bulb shape, any application	465W LED - Non-Int. Ballast	Electronic	N/A	N/A	465	15
LED466-FIXT	LED466W	Non-Integrated Ballast LED, 466W, any bulb shape, any application	466W LED - Non-Int. Ballast	Electronic	N/A	N/A	466	15
LED467-FIXT	LED467W	Non-Integrated Ballast LED, 467W, any bulb shape, any application	467W LED - Non-Int. Ballast	Electronic	N/A	N/A	467	15
LED468-FIXT	LED468W	Non-Integrated Ballast LED, 468W, any bulb shape, any application	468W LED - Non-Int. Ballast	Electronic	N/A	N/A	468	15
LED469-FIXT	LED469W	Non-Integrated Ballast LED, 469W, any bulb shape, any application	469W LED - Non-Int. Ballast	Electronic	N/A	N/A	469	15
LED470-FIXT	LED470W	Non-Integrated Ballast LED, 470W, any bulb shape, any application	470W LED - Non-Int. Ballast	Electronic	N/A	N/A	470	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED471-FIXT	LED471W	Non-Integrated Ballast LED, 471W, any bulb shape, any application	471W LED - Non-Int. Ballast	Electronic	N/A	N/A	471	15
LED472-FIXT	LED472W	Non-Integrated Ballast LED, 472W, any bulb shape, any application	472W LED - Non-Int. Ballast	Electronic	N/A	N/A	472	15
LED473-FIXT	LED473W	Non-Integrated Ballast LED, 473W, any bulb shape, any application	473W LED - Non-Int. Ballast	Electronic	N/A	N/A	473	15
LED474-FIXT	LED474W	Non-Integrated Ballast LED, 474W, any bulb shape, any application	474W LED - Non-Int. Ballast	Electronic	N/A	N/A	474	15
LED475-FIXT	LED475W	Non-Integrated Ballast LED, 475W, any bulb shape, any application	475W LED - Non-Int. Ballast	Electronic	N/A	N/A	475	15
LED476-FIXT	LED476W	Non-Integrated Ballast LED, 476W, any bulb shape, any application	476W LED - Non-Int. Ballast	Electronic	N/A	N/A	476	15
LED477-FIXT	LED477W	Non-Integrated Ballast LED, 477W, any bulb shape, any application	477W LED - Non-Int. Ballast	Electronic	N/A	N/A	477	15
LED478-FIXT	LED478W	Non-Integrated Ballast LED, 478W, any bulb shape, any application	478W LED - Non-Int. Ballast	Electronic	N/A	N/A	478	15
LED479-FIXT	LED479W	Non-Integrated Ballast LED, 479W, any bulb shape, any application	479W LED - Non-Int. Ballast	Electronic	N/A	N/A	479	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED480-FIXT	LED480W	Non-Integrated Ballast LED, 480W, any bulb shape, any application	480W LED - Non-Int. Ballast	Electronic	N/A	N/A	480	15
LED481-FIXT	LED481W	Non-Integrated Ballast LED, 481W, any bulb shape, any application	481W LED - Non-Int. Ballast	Electronic	N/A	N/A	481	15
LED482-FIXT	LED482W	Non-Integrated Ballast LED, 482W, any bulb shape, any application	482W LED - Non-Int. Ballast	Electronic	N/A	N/A	482	15
LED483-FIXT	LED483W	Non-Integrated Ballast LED, 483W, any bulb shape, any application	483W LED - Non-Int. Ballast	Electronic	N/A	N/A	483	15
LED484-FIXT	LED484W	Non-Integrated Ballast LED, 484W, any bulb shape, any application	484W LED - Non-Int. Ballast	Electronic	N/A	N/A	484	15
LED485-FIXT	LED485W	Non-Integrated Ballast LED, 485W, any bulb shape, any application	485W LED - Non-Int. Ballast	Electronic	N/A	N/A	485	15
LED486-FIXT	LED486W	Non-Integrated Ballast LED, 486W, any bulb shape, any application	486W LED - Non-Int. Ballast	Electronic	N/A	N/A	486	15
LED487-FIXT	LED487W	Non-Integrated Ballast LED, 487W, any bulb shape, any application	487W LED - Non-Int. Ballast	Electronic	N/A	N/A	487	15
LED488-FIXT	LED488W	Non-Integrated Ballast LED, 488W, any bulb shape, any application	488W LED - Non-Int. Ballast	Electronic	N/A	N/A	488	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED489-FIXT	LED489W	Non-Integrated Ballast LED, 489W, any bulb shape, any application	489W LED - Non-Int. Ballast	Electronic	N/A	N/A	489	15
LED490-FIXT	LED490W	Non-Integrated Ballast LED, 490W, any bulb shape, any application	490W LED - Non-Int. Ballast	Electronic	N/A	N/A	490	15
LED491-FIXT	LED491W	Non-Integrated Ballast LED, 491W, any bulb shape, any application	491W LED - Non-Int. Ballast	Electronic	N/A	N/A	491	15
LED492-FIXT	LED492W	Non-Integrated Ballast LED, 492W, any bulb shape, any application	492W LED - Non-Int. Ballast	Electronic	N/A	N/A	492	15
LED493-FIXT	LED493W	Non-Integrated Ballast LED, 493W, any bulb shape, any application	493W LED - Non-Int. Ballast	Electronic	N/A	N/A	493	15
LED494-FIXT	LED494W	Non-Integrated Ballast LED, 494W, any bulb shape, any application	494W LED - Non-Int. Ballast	Electronic	N/A	N/A	494	15
LED495-FIXT	LED495W	Non-Integrated Ballast LED, 495W, any bulb shape, any application	495W LED - Non-Int. Ballast	Electronic	N/A	N/A	495	15
LED496-FIXT	LED496W	Non-Integrated Ballast LED, 496W, any bulb shape, any application	496W LED - Non-Int. Ballast	Electronic	N/A	N/A	496	15
LED497-FIXT	LED497W	Non-Integrated Ballast LED, 497W, any bulb shape, any application	497W LED - Non-Int. Ballast	Electronic	N/A	N/A	497	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
LED498-FIXT	LED498W	Non-Integrated Ballast LED, 498W, any bulb shape, any application	498W LED - Non-Int. Ballast	Electronic	N/A	N/A	498	15
LED499-FIXT	LED499W	Non-Integrated Ballast LED, 499W, any bulb shape, any application	499W LED - Non-Int. Ballast	Electronic	N/A	N/A	499	15
LED500-FIXT	LED500W	Non-Integrated Ballast LED, 500W, any bulb shape, any application	500W LED - Non-Int. Ballast	Electronic	N/A	N/A	500	15
LED505-FIXT	LED505W	Non-Integrated Ballast LED, 505W, any bulb shape, any application	505W LED - Non-Int. Ballast	Electronic	N/A	N/A	505	15
LED510-FIXT	LED510W	Non-Integrated Ballast LED, 510W, any bulb shape, any application	510W LED - Non-Int. Ballast	Electronic	N/A	N/A	510	15
LED515-FIXT	LED515W	Non-Integrated Ballast LED, 515W, any bulb shape, any application	515W LED - Non-Int. Ballast	Electronic	N/A	N/A	515	15
LED520-FIXT	LED520W	Non-Integrated Ballast LED, 520W, any bulb shape, any application	520W LED - Non-Int. Ballast	Electronic	N/A	N/A	520	15
LED525-FIXT	LED525W	Non-Integrated Ballast LED, 525W, any bulb shape, any application	525W LED - Non-Int. Ballast	Electronic	N/A	N/A	525	15
LED530-FIXT	LED530W	Non-Integrated Ballast LED, 530W, any bulb shape, any application	530W LED - Non-Int. Ballast	Electronic	N/A	N/A	530	15

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
LED535-FIXT	LED535W	Non-Integrated Ballast LED, 535W, any bulb shape, any application	535W LED - Non-Int. Ballast	Electronic	N/A	N/A	535	15
LED540-FIXT	LED540W	Non-Integrated Ballast LED, 540W, any bulb shape, any application	540W LED - Non-Int. Ballast	Electronic	N/A	N/A	540	15
LED545-FIXT	LED545W	Non-Integrated Ballast LED, 545W, any bulb shape, any application	545W LED - Non-Int. Ballast	Electronic	N/A	N/A	545	15
LED550-FIXT	LED550W	Non-Integrated Ballast LED, 550W, any bulb shape, any application	550W LED - Non-Int. Ballast	Electronic	N/A	N/A	550	15
CF		Compact Fluorescent Fixtures						
CF2/1-SCRW	CF2W	Compact Fluorescent, (1) 2W screw-in lamp/base w/ permanent disk installed, any bulb shape	2W CFL	Mag. or Elec.	1	2	2	2.5
CF3/1-SCRW	CF3W	Compact Fluorescent, (1) 3W screw-in lamp/base w/ permanent disk installed, any bulb shape	3W CFL	Mag. or Elec.	1	3	3	2.5
CF4/1-SCRW	CF4W	Compact Fluorescent, (1) 4W screw-in lamp/base w/ permanent disk installed, any bulb shape	4W CFL	Mag. or Elec.	1	4	4	2.5
CF5/1-SCRW	CF5W	Compact Fluorescent, (1) 5W screw-in lamp/base w/ permanent disk installed, any bulb shape	5W CFL	Mag. or Elec.	1	5	5	2.5
CF6/1-SCRW	CF6W	Compact Fluorescent, (1) 6W screw-in lamp/base w/ permanent disk installed, any bulb shape	6W CFL	Mag. or Elec.	1	6	6	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF7/1-SCRW	CF7W	Compact Fluorescent, (1) 7W screw-in lamp/base w/ permanent disk installed, any bulb shape	7W CFL	Mag. or Elec.	1	7	7	2.5
CF8/1-SCRW	CF8W	Compact Fluorescent, (1) 8W screw-in lamp/base w/ permanent disk installed, any bulb shape	8W CFL	Mag. or Elec.	1	8	8	2.5
CF9/1-SCRW	CF9W	Compact Fluorescent, (1) 9W screw-in lamp/base w/ permanent disk installed, any bulb shape	9W CFL	Mag. or Elec.	1	9	9	2.5
CF10/1-SCRW	CF10W	Compact Fluorescent, (1) 10W screw-in lamp/base w/ permanent disk installed, any bulb shape	10W CFL	Mag. or Elec.	1	10	10	2.5
CF11/1-SCRW	CF11W	Compact Fluorescent, (1) 11W screw-in lamp/base w/ permanent disk installed, any bulb shape	11W CFL	Mag. or Elec.	1	11	11	2.5
CF12/1-SCRW	CF12W	Compact Fluorescent, (1) 12W screw-in lamp/base w/ permanent disk installed, any bulb shape	12W CFL	Mag. or Elec.	1	12	12	2.5
CF13/1-SCRW	CF13W	Compact Fluorescent, (1) 13W screw-in lamp/base w/ permanent disk installed, any bulb shape	13W CFL	Mag. or Elec.	1	13	13	2.5
CF14/1-SCRW	CF14W	Compact Fluorescent, (1) 14W screw-in lamp/base w/ permanent disk installed, any bulb shape	14W CFL	Mag. or Elec.	1	14	14	2.5
CF15/1-SCRW	CF15W	Compact Fluorescent, (1) 15W screw-in lamp/base w/ permanent disk installed, any bulb shape	15W CFL	Mag. or Elec.	1	15	15	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF16/1-SCRW	CF16W	Compact Fluorescent, (1) 16W screw-in lamp/base w/ permanent disk installed, any bulb shape	16W CFL	Mag. or Elec.	1	16	16	2.5
CF17/1-SCRW	CF17W	Compact Fluorescent, (1) 17W screw-in lamp/base w/ permanent disk installed, any bulb shape	17W CFL	Mag. or Elec.	1	17	17	2.5
CF18/1-SCRW	CF18W	Compact Fluorescent, (1) 18W screw-in lamp/base w/ permanent disk installed, any bulb shape	18W CFL	Mag. or Elec.	1	18	18	2.5
CF19/1-SCRW	CF19W	Compact Fluorescent, (1) 19W screw-in lamp/base w/ permanent disk installed, any bulb shape	19W CFL	Mag. or Elec.	1	19	19	2.5
CF20/1-SCRW	CF20W	Compact Fluorescent, (1) 20W screw-in lamp/base w/ permanent disk installed, any bulb shape	20W CFL	Mag. or Elec.	1	20	20	2.5
CF21/1-SCRW	CF21W	Compact Fluorescent, (1) 21W screw-in lamp/base w/ permanent disk installed, any bulb shape	21W CFL	Mag. or Elec.	1	21	21	2.5
CF22/1-SCRW	CF22W	Compact Fluorescent, (1) 22W screw-in lamp/base w/ permanent disk installed, any bulb shape	22W CFL	Mag. or Elec.	1	22	22	2.5
CF23/1-SCRW	CF23W	Compact Fluorescent, (1) 23W screw-in lamp/base w/ permanent disk installed, any bulb shape	23W CFL	Mag. or Elec.	1	23	23	2.5
CF24/1-SCRW	CF24W	Compact Fluorescent, (1) 24W screw-in lamp/base w/ permanent disk installed, any bulb shape	24W CFL	Mag. or Elec.	1	24	24	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF25/1-SCRW	CF25W	Compact Fluorescent, (1) 25W screw-in lamp/base w/ permanent disk installed, any bulb shape	25W CFL	Mag. or Elec.	1	25	25	2.5
CF26/1-SCRW	CF26W	Compact Fluorescent, (1) 26W screw-in lamp/base w/ permanent disk installed, any bulb shape	26W CFL	Mag. or Elec.	1	26	26	2.5
CF27/1-SCRW	CF27W	Compact Fluorescent, (1) 27W screw-in lamp/base w/ permanent disk installed, any bulb shape	27W CFL	Mag. or Elec.	1	27	27	2.5
CF28/1-SCRW	CF28W	Compact Fluorescent, (1) 28W screw-in lamp/base w/ permanent disk installed, any bulb shape	28W CFL	Mag. or Elec.	1	28	28	2.5
CF29/1-SCRW	CF29W	Compact Fluorescent, (1) 29W screw-in lamp/base w/ permanent disk installed, any bulb shape	29W CFL	Mag. or Elec.	1	29	29	2.5
CF30/1-SCRW	CF30W	Compact Fluorescent, (1) 30W screw-in lamp/base w/ permanent disk installed, any bulb shape	30W CFL	Mag. or Elec.	1	30	30	2.5
CF31/1-SCRW	CF31W	Compact Fluorescent, (1) 31W screw-in lamp/base w/ permanent disk installed, any bulb shape	31W CFL	Mag. or Elec.	1	31	31	2.5
CF32/1-SCRW	CF32W	Compact Fluorescent, (1) 32W screw-in lamp/base w/ permanent disk installed, any bulb shape	32W CFL	Mag. or Elec.	1	32	32	2.5
CF33/1-SCRW	CF33W	Compact Fluorescent, (1) 33W screw-in lamp/base w/ permanent disk installed, any bulb shape	33W CFL	Mag. or Elec.	1	33	33	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF34/1-SCRW	CF34W	Compact Fluorescent, (1) 34W screw-in lamp/base w/ permanent disk installed, any bulb shape	34W CFL	Mag. or Elec.	1	34	34	2.5
CF35/1-SCRW	CF35W	Compact Fluorescent, (1) 35W screw-in lamp/base w/ permanent disk installed, any bulb shape	35W CFL	Mag. or Elec.	1	35	35	2.5
CF36/1-SCRW	CF36W	Compact Fluorescent, (1) 36W screw-in lamp/base w/ permanent disk installed, any bulb shape	36W CFL	Mag. or Elec.	1	36	36	2.5
CF37/1-SCRW	CF37W	Compact Fluorescent, (1) 37W screw-in lamp/base w/ permanent disk installed, any bulb shape	37W CFL	Mag. or Elec.	1	37	37	2.5
CF38/1-SCRW	CF38W	Compact Fluorescent, (1) 38W screw-in lamp/base w/ permanent disk installed, any bulb shape	38W CFL	Mag. or Elec.	1	38	38	2.5
CF39/1-SCRW	CF39W	Compact Fluorescent, (1) 39W screw-in lamp/base w/ permanent disk installed, any bulb shape	39W CFL	Mag. or Elec.	1	39	39	2.5
CF40/1-SCRW	CF40W	Compact Fluorescent, (1) 40W screw-in lamp/base w/ permanent disk installed, any bulb shape	40W CFL	Mag. or Elec.	1	40	40	2.5
CF41/1-SCRW	CF41W	Compact Fluorescent, (1) 41W screw-in lamp/base w/ permanent disk installed, any bulb shape	41W CFL	Mag. or Elec.	1	41	41	2.5
CF42/1-SCRW	CF42W	Compact Fluorescent, (1) 42W screw-in lamp/base w/ permanent disk installed, any bulb shape	42W CFL	Mag. or Elec.	1	42	42	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF43/1-SCRW	CF43W	Compact Fluorescent, (1) 43W screw-in lamp/base w/ permanent disk installed, any bulb shape	43W CFL	Mag. or Elec.	1	43	43	2.5
CF44/1-SCRW	CF44W	Compact Fluorescent, (1) 44W screw-in lamp/base w/permanent disk installed, any bulb shape	44W CFL	Mag. or Elec.	1	44	44	2.5
CF45/1-SCRW	CF45W	Compact Fluorescent, (1) 45W screw-in lamp/base w/permanent disk installed, any bulb shape	45W CFL	Mag. or Elec.	1	45	45	2.5
CF46/1-SCRW	CF46W	Compact Fluorescent, (1) 46W screw-in lamp/base w/permanent disk installed, any bulb shape	46W CFL	Mag. or Elec.	1	46	46	2.5
CF47/1-SCRW	CF47W	Compact Fluorescent, (1) 47W screw-in lamp/base w/permanent disk installed, any bulb shape	47W CFL	Mag. or Elec.	1	47	47	2.5
CF48/1-SCRW	CF48W	Compact Fluorescent, (1) 48W screw-in lamp/base w/permanent disk installed, any bulb shape	48W CFL	Mag. or Elec.	1	48	48	2.5
CF49/1-SCRW	CF49W	Compact Fluorescent, (1) 49W screw-in lamp/base w/permanent disk installed, any bulb shape	49W CFL	Mag. or Elec.	1	49	49	2.5
CF50/1-SCRW	CF50W	Compact Fluorescent, (1) 50W screw-in lamp/base w/permanent disk installed, any bulb shape	50W CFL	Mag. or Elec.	1	50	50	2.5
CF51/1-SCRW	CF51W	Compact Fluorescent, (1) 51W screw-in lamp/base w/permanent disk installed, any bulb shape	51W CFL	Mag. or Elec.	1	51	51	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF52/1-SCRW	CF52W	Compact Fluorescent, (1) 52W screw-in lamp/base w/permanent disk installed, any bulb shape	52W CFL	Mag. or Elec.	1	52	52	2.5
CF53/1-SCRW	CF53W	Compact Fluorescent, (1) 53W screw-in lamp/base w/permanent disk installed, any bulb shape	53W CFL	Mag. or Elec.	1	53	53	2.5
CF54/1-SCRW	CF54W	Compact Fluorescent, (1) 54W screw-in lamp/base w/permanent disk installed, any bulb shape	54W CFL	Mag. or Elec.	1	54	54	2.5
CF55/1-SCRW	CF55W	Compact Fluorescent, (1) 55W screw-in lamp/base w/permanent disk installed, any bulb shape	55W CFL	Mag. or Elec.	1	55	55	2.5
CF56/1-SCRW	CF56W	Compact Fluorescent, (1) 56W screw-in lamp/base w/permanent disk installed, any bulb shape	56W CFL	Mag. or Elec.	1	56	56	2.5
CF57/1-SCRW	CF57W	Compact Fluorescent, (1) 57W screw-in lamp/base w/permanent disk installed, any bulb shape	57W CFL	Mag. or Elec.	1	57	57	2.5
CF58/1-SCRW	CF58W	Compact Fluorescent, (1) 58W screw-in lamp/base w/permanent disk installed, any bulb shape	58W CFL	Mag. or Elec.	1	58	58	2.5
CF59/1-SCRW	CF59W	Compact Fluorescent, (1) 59W screw-in lamp/base w/permanent disk installed, any bulb shape	59W CFL	Mag. or Elec.	1	59	59	2.5
CF60/1-SCRW	CF60W	Compact Fluorescent, (1) 60W screw-in lamp/base w/permanent disk installed, any bulb shape	60W CFL	Mag. or Elec.	1	60	60	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF61/1-SCRW	CF61W	Compact Fluorescent, (1) 61W screw-in lamp/base w/permanent disk installed, any bulb shape	61W CFL	Mag. or Elec.	1	61	61	2.5
CF62/1-SCRW	CF62W	Compact Fluorescent, (1) 62W screw-in lamp/base w/permanent disk installed, any bulb shape	62W CFL	Mag. or Elec.	1	62	62	2.5
CF63/1-SCRW	CF63W	Compact Fluorescent, (1) 63W screw-in lamp/base w/permanent disk installed, any bulb shape	63W CFL	Mag. or Elec.	1	63	63	2.5
CF64/1-SCRW	CF64W	Compact Fluorescent, (1) 64W screw-in lamp/base w/permanent disk installed, any bulb shape	64W CFL	Mag. or Elec.	1	64	64	2.5
CF65/1-SCRW	CF65W	Compact Fluorescent, (1) 65W screw-in lamp/base w/permanent disk installed, any bulb shape	65W CFL	Mag. or Elec.	1	65	65	2.5
CF66/1-SCRW	CF66W	Compact Fluorescent, (1) 66W screw-in lamp/base w/permanent disk installed, any bulb shape	66W CFL	Mag. or Elec.	1	66	66	2.5
CF67/1-SCRW	CF67W	Compact Fluorescent, (1) 67W screw-in lamp/base w/permanent disk installed, any bulb shape	67W CFL	Mag. or Elec.	1	67	67	2.5
CF68/1-SCRW	CF68W	Compact Fluorescent, (1) 68W screw-in lamp/base w/permanent disk installed, any bulb shape	68W CFL	Mag. or Elec.	1	68	68	2.5
CF69/1-SCRW	CF69W	Compact Fluorescent, (1) 69W screw-in lamp/base w/permanent disk installed, any bulb shape	69W CFL	Mag. or Elec.	1	69	69	2.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
CF70/1-SCRW	CF70W	Compact Fluorescent, (1) 70W screw-in lamp/base w/permanent disk installed, any bulb shape	70W CFL	Mag. or Elec.	1	70	70	2.5
CF71/1-SCRW	CF71W	Compact Fluorescent, (1) 71W screw-in lamp/base w/permanent disk installed, any bulb shape	71W CFL	Mag. or Elec.	1	71	71	2.5
CF72/1-SCRW	CF72W	Compact Fluorescent, (1) 72W screw-in lamp/base w/permanent disk installed, any bulb shape	72W CFL	Mag. or Elec.	1	72	72	2.5
CF73/1-SCRW	CF73W	Compact Fluorescent, (1) 73W screw-in lamp/base w/permanent disk installed, any bulb shape	73W CFL	Mag. or Elec.	1	73	73	2.5
CF74/1-SCRW	CF74W	Compact Fluorescent, (1) 74W screw-in lamp/base w/permanent disk installed, any bulb shape	74W CFL	Mag. or Elec.	1	74	74	2.5
CF75/1-SCRW	CF75W	Compact Fluorescent, (1) 75W screw-in lamp/base w/permanent disk installed, any bulb shape	75W CFL	Mag. or Elec.	1	75	75	2.5
CF80/1-SCRW	CF80W	Compact Fluorescent, (1) 80W screw-in lamp/base w/permanent disk installed, any bulb shape	80W CFL	Mag. or Elec.	1	80	80	2.5
CF85/1-SCRW	CF85W	Compact Fluorescent, (1) 85W screw-in lamp/base w/permanent disk installed, any bulb shape	85W CFL	Mag. or Elec.	1	85	85	2.5
CF100/1-SCRW	CF100W	Compact Fluorescent, (1) 100W screw-in lamp/base w/ permanent disk installed, any bulb shape	100W CFL	Mag. or Elec.	1	100	100	2.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CF125/1-SCRW	CF125W	Compact Fluorescent, (1) 125W screw-in lamp/base w/ permanent disk installed, any bulb shape	125W CFL	Mag. or Elec.	1	125	125	2.5
CF150/1-SCRW	CF150W	Compact Fluorescent, (1) 150W screw-in lamp/base w/ permanent disk installed, any bulb shape	150W CFL	Mag. or Elec.	1	150	150	2.5
CF200/1-SCRW	CF200W	Compact Fluorescent, (1) 200W screw-in lamp/base w/ permanent disk installed, any bulb shape	200W CFL	Mag. or Elec.	1	200	200	2.5
CFC2/1-SCRW	CFC2W	Compact Fluorescent, Cold Cathode, (1) 2W screw-in lamp/base w/ permanent locking device, any bulb shape	2W Cold Cathode	Electronic	1	2	2	4.5
CFC2/2-SCRW	CFC2W	Compact Fluorescent, Cold Cathode, (2) 2W screw-in lamp/base w/ permanent locking device, any bulb shape	4W Cold Cathode	Electronic	2	2	4	4.5
CFC3/1-SCRW	CFC3W	Compact Fluorescent, Cold Cathode, (1) 3W screw-in lamp/base w/ permanent locking device, any bulb shape	3W Cold Cathode	Electronic	1	3	3	4.5
CFC3/2-SCRW	CFC3W	Compact Fluorescent, Cold Cathode, (2) 3W screw-in lamp/base w/ permanent locking device, any bulb shape	6W Cold Cathode	Electronic	2	3	6	4.5
CFC4/1-SCRW	CFC4W	Compact Fluorescent, Cold Cathode, (1) 4W screw-in lamp/base w/ permanent locking device, any bulb shape	4W Cold Cathode	Electronic	1	4	4	4.5
CFC4/2-SCRW	CFC4W	Compact Fluorescent, Cold Cathode, (2) 4W screw-in lamp/base w/ permanent locking device, any bulb shape	8W Cold Cathode	Electronic	2	4	8	4.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
CFC5/1-SCRW	CFC5W	Compact Fluorescent, Cold Cathode, (1) 5W screw-in lamp/base w/ permanent locking device, any bulb shape	5W Cold Cathode	Electronic	1	5	5	4.5
CFC5/2-SCRW	CFC5W	Compact Fluorescent, Cold Cathode, (2) 5W screw-in lamp/base w/ permanent locking device, any bulb shape	10W Cold Cathode	Electronic	2	5	10	4.5
CFC8/1-SCRW	CFC8W	Compact Fluorescent, Cold Cathode, (1) 8W screw-in lamp/base w/ permanent locking device, any bulb shape	8W Cold Cathode	Electronic	1	8	8	4.5
CFC8/2-SCRW	CFC8W	Compact Fluorescent, Cold Cathode, (2) 8W screw-in lamp/base w/ permanent locking device, any bulb shape	16W Cold Cathode	Electronic	2	8	16	4.5
CFC13/1-SCRW	CFC13W	Compact Fluorescent, Cold Cathode, (1) 13W screw-in lamp/base w/ permanent locking device, any bulb shape	13W Cold Cathode	Electronic	1	13	13	4.5
CFC18/1-SCRW	CFC18W	Compact Fluorescent, Cold Cathode, (1) 18W screw-in lamp/base w/ permanent locking device, any bulb shape	18W Cold Cathode	Electronic	1	18	18	4.5
CFD10/1	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	1-Lamp 10W CFL 2D	Mag-STD	1	10	16	16
CFD10/1-L	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	1-Lamp 10W CFL 2D	Electronic	1	10	14	16
CFD16/1	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	1-Lamp 16W CFL 2D	Mag-STD	1	16	26	16
CFD16/1-L	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	1-Lamp 16W CFL 2D	Electronic	1	16	18	16
CFD21/1	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	1-Lamp 21W CFL 2D	Mag-STD	1	21	26	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFD21/1-L	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	1-Lamp 21W CFL 2D	Electronic	1	21	22	16
CFD28/1	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	1-Lamp 28W CFL 2D	Mag-STD	1	28	35	16
CFD28/1-L	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	1-Lamp 28W CFL 2D	Electronic	1	28	29	16
CFD38/1	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	1-Lamp 38W CFL 2D	Mag-STD	1	38	46	16
CFD38/1-L	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	1-Lamp 38W CFL 2D	Electronic	1	38	32	16
CFG13/1-L	CFG13W	Compact Fluorescent, Multi, GU24 with Integrated Ballast, (1) 13W lamp	1-Lamp 13W CFL Multi	Electronic	1	13	13	16
CFG18/1-L	CFG18W	Compact Fluorescent, Multi, GU24 with Integrated Ballast, (1) 18W lamp	1-Lamp 18W CFL Multi	Electronic	1	18	18	16
CFG23/1-L	CFG23W	Compact Fluorescent, Multi, GU24 with Integrated Ballast, (1) 23W lamp	1-Lamp 23W CFL Multi	Electronic	1	23	23	16
CFG26/1-L	CFG26W	Compact Fluorescent, Multi, GU24 with Integrated Ballast, (1) 26W lamp	1-Lamp 26W CFL Multi	Electronic	1	26	26	16
CFG32/1-L	CFG32W	Compact Fluorescent, Multi, GU24 with Integrated Ballast, (1) 32W lamp	1-Lamp 32W CFL Multi	Electronic	1	32	32	16
CFG42/1-L	CFG42W	Compact Fluorescent, Multi, GU24 with Integrated Ballast, (1) 42W lamp	1-Lamp 42W CFL Multi	Electronic	1	42	42	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFM13/1-L	CFM13W	Compact Fluorescent, Multi, 4-pin, (1) 13W lamp	1-Lamp 13W CFL Multi 4-Pin	Electronic	1	13	16	16
CFM13/2-L	CFM13W	Compact Fluorescent, Multi, 4-pin, (2) 13W lamps	2-Lamp 13W CFL Multi 4-Pin	Electronic	2	13	30	16
CFM15/1-L	CFM15W	Compact Fluorescent, Multi, 4-pin, (1) 15W lamp	1-Lamp 15W CFL Multi 4-Pin	Electronic	1	15	18	16
CFM18/1-L	CFM18W	Compact Fluorescent, Multi, 4-pin, (1) 18W lamp	1-Lamp 18W CFL Multi 4-Pin	Electronic	1	18	20	16
CFM18/2-L	CFM18W	Compact Fluorescent, Multi, 4-pin, (2) 18W lamps	2-Lamp 18W CFL Multi 4-Pin	Electronic	2	18	40	16
CFM21/1-L	CFM21W	Compact Fluorescent, Multi, 4-pin, (1) 21W lamp	1-Lamp 21W CFL Multi 4-Pin	Electronic	1	21	23	16
CFM26/1-L	CFM26W	Compact Fluorescent, Multi, 4-pin, (1) 26W lamp	1-Lamp 26W CFL Multi 4-Pin	Electronic	1	26	29	16
CFM26/2-L	CFM26W	Compact Fluorescent, Multi, 4-pin, (2) 26W lamps	2-Lamp 26W CFL Multi 4-Pin	Electronic	2	26	51	16
CFM28/1-L	CFM28W	Compact Fluorescent, Multi, 4-pin, (1) 28W lamp	1-Lamp 28W CFL Multi 4-Pin	Electronic	1	28	31	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFM32/1-L	CFM32W	Compact Fluorescent, Multi, 4-pin, (1) 32W lamp	1-Lamp 32W CFL Multi 4-Pin	Electronic	1	32	35	16
CFM42/1-L	CFM42W	Compact Fluorescent, Multi, 4-pin, (1) 42W lamp	1-Lamp 42W CFL Multi 4-Pin	Electronic	1	42	46	16
CFM42/2-L	CFM42W	Compact Fluorescent, Multi, 4-pin, (2) 42W lamps	2-Lamp 42W CFL Multi 4-Pin	Electronic	2	42	93	16
CFM42/8-L	CFM42W	Compact Fluorescent, Multi, 4-pin, (8) 42W lamps, (4) 2-lamp ballasts	8-Lamp 42W CFL Multi 4-Pin	Electronic	8	42	372	16
CFM57/1-L	CFM57W	Compact Fluorescent, Multi, 4-pin, (1) 57W lamp	1-Lamp 57W CFL Multi 4-Pin	Electronic	1	57	59	16
CFM60/1-L	CFM60W	Compact Fluorescent, Multi, 4-pin, (1) 60W lamp	1-Lamp 60W CFL Multi 4-Pin	Electronic	1	60	70	16
CFM70/1-L	CFM70W	Compact Fluorescent, Multi, 4-pin, (1) 70W lamp	1-Lamp 70W CFL Multi 4-Pin	Electronic	1	70	73	16
CFM85/1-L	CFM85W	Compact Fluorescent, Multi, 4-pin, (1) 85W lamp	1-Lamp 85W CFL Multi 4-Pin	Electronic	1	85	96	16
CFM120/1-L	CFM120W	Compact Fluorescent, Multi, 4-pin, (1) 120W lamp	1-Lamp 120W CFL Multi 4-Pin	Electronic	1	120	135	16
CFQ9/1	CFQ9W	Compact Fluorescent, Quad, (1) 9W lamp	1-Lamp 9W CFL Quad	Mag-STD	1	9	14	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFQ9/2	CFQ9W	Compact Fluorescent, Quad, (2) 9W lamps	2-Lamp 9W CFL Quad	Mag-STD	2	9	23	16
CFQ10/1	CFQ10W	Compact Fluorescent, quad, (1) 10W lamp	1-Lamp 10W CFL Quad	Mag-STD	1	10	15	16
CFQ13/1	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp	1-Lamp 13W CFL Quad	Mag-STD	1	13	17	16
CFQ13/1-L	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp, BF=1.05	1-Lamp 13W CFL Quad	Electronic	1	13	15	16
CFQ13/2	CFQ13W	Compact Fluorescent, quad, (2) 13W lamps	2-Lamp 13W CFL Quad	Mag-STD	2	13	31	16
CFQ13/2-L	CFQ13W	Compact Fluorescent, quad, (2) 13W lamps, BF=1.0	2-Lamp 13W CFL Quad	Electronic	2	13	28	16
CFQ13/3	CFQ13W	Compact Fluorescent, quad, (3) 13W lamps	3-Lamp 13W CFL Quad	Mag-STD	3	13	48	16
CFQ15/1	CFQ15W	Compact Fluorescent, quad, (1) 15W lamp	1-Lamp 15W CFL Quad	Mag-STD	1	15	20	16
CFQ17/1	CFQ17W	Compact Fluorescent, quad, (1) 17W lamp	1-Lamp 17W CFL Quad	Mag-STD	1	17	24	16
CFQ17/2	CFQ17W	Compact Fluorescent, quad, (2) 17W lamps	2-Lamp 17W CFL Quad	Mag-STD	2	17	48	16
CFQ18/1	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp	1-Lamp 18W CFL Quad	Mag-STD	1	18	26	16
CFQ18/1-L	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp, BF=1.0	1-Lamp 18W CFL Quad	Electronic	1	18	20	16
CFQ18/2	CFQ18W	Compact Fluorescent, quad, (2) 18W lamps	2-Lamp 18W CFL Quad	Mag-STD	2	18	45	16
CFQ18/2-L	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp, BF=1.0	2-Lamp 18W CFL Quad	Electronic	2	18	38	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFQ18/4	CFQ18W	Compact Fluorescent, quad, (4) 18W lamps	4-Lamp 18W CFL Quad	Mag-STD	2	18	90	16
CFQ20/1	CFQ20W	Compact Fluorescent, quad, (1) 20W lamp	1-Lamp 20W CFL Quad	Mag-STD	1	20	23	16
CFQ20/2	CFQ20W	Compact Fluorescent, quad, (2) 20W lamps	2-Lamp 20W CFL Quad	Mag-STD	2	20	46	16
CFQ22/1	CFQ22W	Compact Fluorescent, Quad, (1) 22W lamp	1-Lamp 22W CFL Quad	Mag-STD	1	22	24	16
CFQ22/2	CFQ22W	Compact Fluorescent, Quad, (2) 22W lamps	2-Lamp 22W CFL Quad	Mag-STD	2	22	48	16
CFQ22/3	CFQ22W	Compact Fluorescent, Quad, (3) 22W lamps	3-Lamp 22W CFL Quad	Mag-STD	3	22	72	16
CFQ23/1	CFQ23W	Compact Fluorescent, Quad, (1) 23W lamp	1-Lamp 23W CFL Quad	Mag-STD	1	23	27	16
CFQ25/1	CFQ25W	Compact Fluorescent, Quad, (1) 25W lamp	1-Lamp 25W CFL Quad	Mag-STD	1	25	33	16
CFQ25/2	CFQ25W	Compact Fluorescent, Quad, (2) 25W lamps	2-Lamp 25W CFL Quad	Mag-STD	2	25	66	16
CFQ26/1	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp	1-Lamp 26W CFL Quad	Mag-STD	1	26	33	16
CFQ26/1-L	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp, BF=0.95	1-Lamp 26W CFL Quad	Electronic	1	26	27	16
CFQ26/2	CFQ26W	Compact Fluorescent, quad, (2) 26W lamps	2-Lamp 26W CFL Quad	Mag-STD	2	26	66	16
CFQ26/2-L	CFQ26W	Compact Fluorescent, quad, (2) 26W lamps, BF=0.95	2-Lamp 26W CFL Quad	Electronic	2	26	50	16
CFQ26/3	CFQ26W	Compact Fluorescent, quad, (3) 26W lamps	3-Lamp 26W CFL Quad	Mag-STD	3	26	99	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFQ26/6-L	CFQ26W	Compact Fluorescent, quad, (6) 26W lamps, BF=0.95	6-Lamp 26W CFL Quad	Electronic	6	26	150	16
CFQ28/1	CFQ28W	Compact Fluorescent, quad, (1) 28W lamp	1-Lamp 28W CFL Quad	Mag-STD	1	28	33	16
CFQ28/1-L	CFQ28W	Compact Fluorescent, quad, (1) 28W lamp	1-Lamp 28W CFL Quad	Electronic	1	28	31	16
CFQ28/2-L	CFQ28W	Compact Fluorescent, quad, (2) 28W lamps	2-Lamp 28W CFL Quad	Electronic	2	28	60	16
CFT5/1	CFT5W	Compact Fluorescent, twin, (1) 5W lamp	1-Lamp 5W CFL Twin	Mag-STD	1	5	9	16
CFT5/2	CFT5W	Compact Fluorescent, long twin, (2) 5W lamps	2-Lamp 5W CFL Twin	Mag-STD	2	5	18	16
CFT7/1	CFT7W	Compact Fluorescent, twin, (1) 7W lamp	1-Lamp 7W CFL Twin	Mag-STD	1	7	10	16
CFT7/2	CFT7W	Compact Fluorescent, twin, (2) 7W lamps	2-Lamp 7W CFL Twin	Mag-STD	2	7	21	16
CFT9/1	CFT9W	Compact Fluorescent, twin, (1) 9W lamp	1-Lamp 9W CFL Twin	Mag-STD	1	9	12	16
CFT9/2	CFT9W	Compact Fluorescent, twin, (2) 9W lamps	2-Lamp 9W CFL Twin	Mag-STD	2	9	23	16
CFT9/3	CFT9W	Compact Fluorescent, twin, (3) 9 W lamps	3-Lamp 9W CFL Twin	Mag-STD	3	9	34	16
CFT13/1	CFT13W	Compact Fluorescent, twin, (1) 13W lamp	1-Lamp 13W CFL Twin	Mag-STD	1	13	17	16
CFT13/1-L	CFT13W	Compact Fluorescent, twin, (1) 13W lamp	1-Lamp 13W CFL Twin	Electronic	1	13	15	16
CFT13/2	CFT13W	Compact Fluorescent, twin, (2) 13W lamps	2-Lamp 13W CFL Twin	Mag-STD	2	13	31	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFT13/2-L	CFT13W	Compact Fluorescent, twin, (2) 13W lamps	2-Lamp 13W CFL Twin	Electronic	2	13	28	16
CFT13/3	CFT13W	Compact Fluorescent, twin, (3) 13 W lamps	3-Lamp 13W CFL Twin	Mag-STD	3	13	48	16
CFT18/1	CFT18W	Compact Fluorescent, Long twin., (1) 18W lamp	1-Lamp 18W CFL Twin	Mag-STD	1	18	24	16
CFT18/1-L	CFT18W	Compact Fluorescent, twin, (1) 18W lamp	1-Lamp 18W CFL Twin	Electronic	1	18	20	16
CFT18/2	CFT18W	Compact Fluorescent, twin, (2) 18 W lamps	2-Lamp 18W CFL Twin	Mag-STD	2	18	38	16
CFT22/1	CFT22W	Compact Fluorescent, twin, (1) 22W lamp	1-Lamp 22W CFL Twin	Mag-STD	1	22	27	16
CFT22/2	CFT22W	Compact Fluorescent, twin, (2) 22W lamps	2-Lamp 22W CFL Twin	Mag-STD	2	22	54	16
CFT22/4	CFT22W	Compact Fluorescent, twin, (4) 22W lamps	4-Lamp 22W CFL Twin	Mag-STD	4	22	108	16
CFT24/1	CFT24W	Compact Fluorescent, long twin, (1) 24W lamp	1-Lamp 24W CFL Twin	Mag-STD	1	24	32	16
CFT26/1	CFT26W	Compact Fluorescent, twin, (1) 26W lamp	1-Lamp 26W CFL Twin	Mag-STD	1	26	32	16
CFT26/1-L	CFT26W	Compact Fluorescent, twin, (1) 26W lamp	1-Lamp 26W CFL Twin	Electronic	1	26	27	16
CFT26/2-L	CFT26W	Compact Fluorescent, twin, (2) 26W lamps	2-Lamp 26W CFL Twin	Electronic	2	26	51	16
CFT28/1	CFT28W	Compact Fluorescent, twin, (1) 28W lamp	1-Lamp 28W CFL Twin	Mag-STD	1	28	33	16
CFT28/2	CFT28W	Compact Fluorescent, twin, (2) 28W lamps	2-Lamp 28W CFL Twin	Mag-STD	2	28	66	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
CFT32/1-L	CFT32W	Compact Fluorescent, twin, (1) 32W lamp	1-Lamp 32W CFL Twin	Electronic	1	32	34	16
CFT32/2-L	CFT32W	Compact Fluorescent, twin, (2) 32W lamps	2-Lamp 32W CFL Twin	Electronic	2	32	62	16
CFT32/6-L	CFT32W	Compact Fluorescent, twin, (6) 32W lamps	6-Lamp 32W CFL Twin	Electronic	6	32	186	16
CFT36/1	CFT36W	Compact Fluorescent, long twin, (1) 36W lamp	1-Lamp 36W CFL Long Twin	Mag-STD	1	36	51	16
CFT40/1	CFT40W	Compact Fluorescent, long twin, (1) 40W lamp	1-Lamp 40W CFL Long Twin	Mag-STD	1	40	46	16
CFT40/1-L	CFT40W	Compact Fluorescent, long twin, (1) 40W lamp	1-Lamp 40W CFL Long Twin	Electronic	1	40	43	16
CFT40/2	CFT40W	Compact Fluorescent, long twin, (2) 40W lamps	2-Lamp 40W CFL Long Twin	Mag-STD	2	40	85	16
CFT40/2-L	CFT40W	Compact Fluorescent, long twin, (2) 40W lamps	2-Lamp 40W CFL Long Twin	Electronic	2	40	72	16
CFT40/3	CFT40W	Compact Fluorescent, long twin, (3) 40 W lamps	3-Lamp 40W CFL Long Twin	Mag-STD	3	40	133	16
CFT40/3-L	CFT40W	Compact Fluorescent, long twin, (3) 40W lamps	3-Lamp 40W CFL Long Twin	Electronic	3	40	105	16

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
CFT40/5-L	CFT40W	Compact Fluorescent, long twin, (5) 40W lamps	5-Lamp 40W CFL Long Twin	Electronic	5	40	177	16
CFT50/1-L	CFT50W	Compact Fluorescent, long twin, (1) 50W lamp	1-Lamp 50W CFL Long Twin	Electronic	1	50	54	16
CFT50/2-L	CFT50W	Compact Fluorescent, long twin, (2) 50W lamps	1-Lamp 50W CFL Long Twin	Electronic	1	50	108	16
CFT55/1-L	CFT55W	Compact Fluorescent, long twin, (1) 55W lamp	1-Lamp 55W CFL Long Twin	Electronic	1	55	58	16
CFT55/2-L	CFT55W	Compact Fluorescent, long twin, (2) 55W lamps	2-Lamp 55W CFL Long Twin	Electronic	2	55	108	16
CFT55/3-L	CFT55W	Compact Fluorescent, long twin, (3) 55W lamps	3-Lamp 55W CFL Long Twin	Electronic	3	55	168	16
CFT55/4-L	CFT55W	Compact Fluorescent, long twin, (4) 55W lamps	4-Lamp 55W CFL Long Twin	Electronic	4	55	220	16
CFT80/1-L	CFT80W	Compact Fluorescent, long twin, (1) 80W lamp	1-Lamp 80W CFL Long Twin	Electronic	1	80	90	16
ECF		EXIT Sign Fixtures						
ECF5/1	CFT5W	EXIT Compact Fluorescent, (1) 5W lamp	1-Lamp 5W CFL Exit	Mag-STD	1	5	9	16

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
ECF5/2	CFT5W	EXIT Compact Fluorescent, (2) 5W lamps	2-Lamp 5W CFL Exit	Mag-STD	2	5	20	16
ECF6/1	CFT6W	EXIT Compact Fluorescent, (1) 6W lamp	1-Lamp 6W CFL Exit	Mag-STD	1	6	13	16
ECF6/2	CFT6W	EXIT Compact Fluorescent, (2) 6W lamps, (2) ballasts	2-Lamp 6W CFL Exit	Mag-STD	2	6	26	16
ECF7/1	CFT7W	EXIT Compact Fluorescent, (1) 7W lamp	1-Lamp 7W CFL Exit	Mag-STD	1	7	10	16
ECF7/2	CFT7W	EXIT Compact Fluorescent, (2) 7W lamps	2-Lamp 7W CFL Exit	Mag-STD	2	7	21	16
ECF9/1	CFT9W	EXIT Compact Fluorescent, (1) 9W lamp	1-Lamp 9W CFL Exit	Mag-STD	1	9	12	16
ECF9/2	CFT9W	EXIT Compact Fluorescent, (2) 9W lamps	2-Lamp 9W CFL Exit	Mag-STD	2	9	20	16
EF2/2	F2T1	EXIT Sub-miniature T-1 Fluorescent, (2) lamps	2-Lamp 2W T-1 Exit	Electronic	2	2	5	16
EF6/1	F6T5	EXIT Miniature Bi-pin Fluorescent, (1) 6W lamp, (1) ballast	1-Lamp 6W Bi-Pin Fluorescent Exit	Mag-STD	1	6	9	16
EF6/2	F6T5	EXIT Miniature Bi-pin Fluorescent, (2) 6W lamps, (2) ballasts	2-Lamp 6W Bi-Pin Fluorescent Exit	Mag-STD	2	6	18	16
EF8/1	F8T5	EXIT T5 Fluorescent, (1) 8W lamp	1-Lamp 8W T-5 Exit	Mag-STD	1	8	12	16
EF8/2	F8T5	EXIT T5 Fluorescent, (2) 8W lamps	2-Lamp 8W T-5 Exit	Mag-STD	2	8	24	16
EI5/1	I5	EXIT Incandescent, (1) 5W lamp	1-Lamp 5W incandescent Exit		1	5	5	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
EI5/2	I5	EXIT Incandescent, (2) 5W lamps	2-Lamp 5W incandescent Exit		2	5	10	1.5
EI7.5/1	I7.5	EXIT Tungsten, (1) 7.5 W lamp	1-Lamp 7.5W Tungsten Exit		1	7.5	8	1.5
EI7.5/2	I7.5	EXIT Tungsten, (2) 7.5 W lamps	2-Lamp 7.5W Tungsten Exit		2	7.5	15	1.5
EI10/2	I10	EXIT Incandescent, (2) 10W lamps	2-Lamp 10W incandescent Exit		2	10	20	1.5
EI15/1	I15	EXIT Incandescent, (1) 15W lamp	1-Lamp 15W incandescent Exit		1	15	15	1.5
EI15/2	I15	EXIT Incandescent, (2) 15W lamps	2-Lamp 15W incandescent Exit		2	15	30	1.5
EI20/1	I20	EXIT Incandescent, (1) 20W lamp	1-Lamp 20W incandescent Exit		1	20	20	1.5
EI20/2	I20	EXIT Incandescent, (2) 20W lamps	2-Lamp 20W incandescent Exit		2	20	40	1.5
EI25/1	I25	EXIT Incandescent, (1) 25W lamp	1-Lamp 25W incandescent Exit		1	25	25	1.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
EI25/2	I25	EXIT Incandescent, (2) 25W lamps	2-Lamp 25W incandescent Exit		2	25	50	1.5
EI34/1	I34	EXIT Incandescent, (1) 34W lamp	1-Lamp 34W incandescent Exit		1	34	34	1.5
EI34/2	I34	EXIT Incandescent, (2) 34W lamps	2-Lamp 34W incandescent Exit		2	34	68	1.5
EI40/1	I40	EXIT Incandescent, (1) 40W lamp	1-Lamp 40W incandescent Exit		1	40	40	1.5
EI40/2	I40	EXIT Incandescent, (2) 40W lamps	2-Lamp 40W incandescent Exit		2	40	80	1.5
EI50/2	I50	EXIT Incandescent, (2) 50W lamps	2-Lamp 50W incandescent Exit		2	50	100	1.5
EI6/1	6S6	EXIT Incandescent, (1) 6 W lamp	1-Lamp 6W incandescent Exit		1	6	6	1.5
EI6/2	6S6	EXIT Incandescent, (2) 6 W lamps	2-Lamp 6W incandescent Exit		2	6	12	1.5
ELED2/1	LED2W	EXIT Light Emitting Diode, (1) 2W lamp, Single Sided	1-Lamp 2W LED Exit		1	2	6	15
ELED2/2	LED2W	EXIT Light Emitting Diode, (2) 2W lamps, Dual Sided	2-Lamp 2W LED Exit		2	2	9	15

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
ELED3	LED3W	EXIT Light Emitting Diode, (1) 3W lamp, Single Sided	1-Lamp 3W LED Exit		1	3	3	15
EP	P0W	EXIT Photoluminescent, 0W	Photoluminescent Exit Sign		0	0	0	15
FT5		T5 Linear Fluorescent Systems						
F22PS	F13T5	Fluorescent, (2) 21", Preheat T5 lamps, (1) Magnetic ballasts with integral starter, (BF=0.80)	2' 2-Lamp T5	Mag-STD	2	13	26	15.5
F24PS	F13T5	Fluorescent, (4) 21", Preheat T5 lamps, (2) Magnetic ballasts with integral starter (BF=0.80)	2' 4-Lamp T5	Mag-STD	4	13	53	15.5
F21GPL-H	F14T5	Fluorescent (1) 22" (563mm) T-5 lamp; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	2' 1-Lamp T5	PRS Elec.	1	14	18	15.5
F22GPL-H	F14T5	Fluorescent (2) 22" (563mm) T-5 lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	2' 2-Lamp T5	PRS Elec.	2	14	33	15.5
F23GPL-H	F14T5	Fluorescent (3) 22" (563mm)T-5 lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	2' 3-Lamp T5	PRS Elec.	3	14	50	15.5
F23GPL/2-H	F14T5	Fluorescent (3) 22" (563mm)T-5 lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	2' 3-Lamp T5	PRS Elec.	3	14	51	15.5
F24GPL/2-H	F14T5	Fluorescent (4) 22" (563mm)T-5 lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	2' 4-Lamp T5	PRS Elec.	4	14	66	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F31GPL-H	F21T5	Fluorescent (1) 34" (863mm) T-5 lamp; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	3' 1-Lamp T5	PRS Elec.	1	21	25	15.5
F32GPL-H	F21T5	Fluorescent (2) 34" (863mm) T-5 lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	3' 2-Lamp T5	PRS Elec.	2	21	48	15.5
F33GPL/2-H	F21T5	Fluorescent (3) 34" (863mm)T-5 lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	3' 3-Lamp T5	PRS Elec.	3	21	73	15.5
F34GPL/2-H	F21T5	Fluorescent (4) 34" (863mm)T-5 lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	3' 4-Lamp T5	PRS Elec.	4	21	96	15.5
F21GPHL-H	F24T5/HO	Fluorescent (1) 22" (563mm) T-5 HO lamp; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	2' 1-Lamp T5HO	PRS Elec.	1	24	27	15.5
F22GPHL-H	F24T5/HO	Fluorescent (2) 22" (563mm) T-5 HO lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	2' 2-Lamp T5HO	PRS Elec.	2	24	52	15.5
F23GPHL/2-H	F24T5/HO	Fluorescent (3) 22" (563mm)T-5 HO lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	2' 3-Lamp T5HO	PRS Elec.	3	24	79	15.5
F24GPHL/2-H	F24T5/HO	Fluorescent (4) 22" (563mm)T-5 HO lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	2' 4-Lamp T5HO	PRS Elec.	4	24	104	15.5
F26GPHL/3-H	F24T5/HO	Fluorescent (4) 22" (563mm) T-5 HO lamps; (3) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	2' 6-Lamp T5HO	PRS Elec.	6	24	156	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F41GPL-H	F28T5	Fluorescent (1) 45.8" (1163mm) T-5 lamp; (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 1-Lamp T5	PRS Elec.	1	28	33	15.5
F41GPL/T 2-H	F28T5	Fluorescent (1) 45.8" (1163mm) T-5 lamp; Tandem 2-lamp PRS Ballast,HLO (.95 < BF < 1.1)	4' 1-Lamp T5	PRS Elec.	1	28	32	15.5
F42GPL-H	F28T5	Fluorescent (2) 45.8" (1163mm) T-5 lamps; (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 2-Lamp T5	PRS Elec.	2	28	63	15.5
F43GPL/2-H	F28T5	Fluorescent (3) 45.8" (1163mm)T-5 lamps; (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 3-Lamp T5	PRS Elec.	3	28	96	15.5
F44GPL/2-H	F28T5	Fluorescent (4) 45.8" (1163mm)T-5 lamps; (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 4-Lamp T5	PRS Elec.	4	28	126	15.5
F51GPL-H	F35T5	Fluorescent (1) 57.6" (1463mm) T-5 lamp; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	5' 1-Lamp T5	PRS Elec.	1	35	40	15.5
F52GPL-H	F35T5	Fluorescent (2) 57.6" (1463mm) T-5 lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	5' 2-Lamp T5	PRS Elec.	2	35	78	15.5
F53GPL/2-H	F35T5	Fluorescent (3) 57.6" (1463mm)T-5 lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	5' 3-Lamp T5	PRS Elec.	3	35	118	15.5
F54GPL/2-H	F35T5	Fluorescent (4) 57.6" (1463mm)T-5 lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	5' 4-Lamp T5	PRS Elec.	4	35	156	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F31GPHL-H	F39T5/HO	Fluorescent (1) 34" (863mm) T-5 HO lamp; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	3' 1-Lamp T5	PRS Elec.	1	39	44	15.5
F32GPHL-H	F39T5/HO	Fluorescent (2) 34" (863mm) T-5 HO lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	3' 2-Lamp T5	PRS Elec.	2	39	86	15.5
F33GPHL/2-H	F39T5/HO	Fluorescent (3) 34" (863mm)T-5 HO lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	3' 3-Lamp T5	PRS Elec.	3	39	130	15.5
F34GPHL/2-H	F39T5/HO	Fluorescent (4) 34" (863mm)T-5 HO lamps; (2) Prog.Start or PRS Ballasts, HLO (.95 < BF < 1.1)	3' 4-Lamp T5	PRS Elec.	4	39	172	15.5
F46GPRL/2-H	F45T5/HO-RW	Fluorescent, (6) 45.8" T-5 HO reduced-wattage lamps, (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 6-Lamp T5HO	PRS Elec.	6	54	332	15.5
F46GPRL/3-H	F45T5/HO-RW	Fluorescent, (6) 45.8" T-5 HO reduced-wattage lamps, (3) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 6-Lamp T5HO	PRS Elec.	6	54	330	15.5
F41GPHL-H	F54T5/HO	Fluorescent (1) 45.8" T-5 HO lamp, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 1-Lamp T5HO	PRS Elec.	1	54	64	15.5
F41GPHL/T2-H	F54T5/HO	Fluorescent (1) 45.8" T-5 HO lamp, Tandem 2-lamp PRS Ballast, HLO (.95 < BF < 1.1)	4' 1-Lamp T5HO	PRS Elec.	1	54	59	15.5
F42GPHL-H	F54T5/HO	Fluorescent (2) 45.8" T-5 HO lamps, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 2-Lamp T5HO	PRS Elec.	2	54	117	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F43GPHL-H	F54T5/HO	Fluorescent, (3) 45.8" T-5 HO lamps, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 3-Lamp T5HO	PRS Elec.	3	54	181	15.5
F43GPHL/2-H	F54T5/HO	Fluorescent (3) 45.8" T-5 HO lamps, (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 3-Lamp T5HO	PRS Elec.	3	54	181	15.5
F44GPHL-H	F54T5/HO	Fluorescent, (4) 45.8" T-5 HO lamps, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 4-Lamp T5HO	PRS Elec.	4	54	230	15.5
F44GPHL/2-H	F54T5/HO	Fluorescent (4) 45.8" T-5 HO lamps, (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 4-Lamp T5HO	PRS Elec.	4	54	234	15.5
F45GPHL/2-H	F54T5/HO	Fluorescent (5) 45.8" T-5 HO lamps, (2) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 5-Lamp T5HO	PRS Elec.	5	54	298	15.5
F45GPRL/2-H	F54T5/HO-RW	Fluorescent (5) 45.2" T-5 HO reduced-wattage lamp, (2) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 5-Lamp T5HO	PRS Elec.	5	47-51	276	15.5
F46GPHL/2-H	F54T5/HO	Fluorescent, (6) 45.8" T-5 HO lamps, (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 6-Lamp T5HO	PRS Elec.	6	54	362	15.5
F46GPHL/3-H	F54T5/HO	Fluorescent, (6) 45.8" T-5 HO lamps, (3) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 6-Lamp T5HO	PRS Elec.	6	54	351	15.5
F48GPHL/2-H	F54T5/HO	Fluorescent, (8) 45.8" T-5 HO lamps, (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 8-Lamp T5HO	PRS Elec.	8	54	460	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F48GPHL/ 4-H	F54T5/HO	Fluorescent, (8) 45.8" T-5 HO lamps, (4) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 8-Lamp T5HO	PRS Elec.	8	54	468	15.5
F410GPHL /3-H	F54T5/HO	Fluorescent, (10) 45.8" T-5 HO lamps, (3) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 10L T5HO	PRS Elec.	10	54	577	15.5
F410GPHL /5-H	F54T5/HO	Fluorescent, (10) 45.8" T-5 HO lamps, (5) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 10L T5HO	PRS Elec.	10	54	585	15.5
F412GPHL /3-H	F54T5/HO	Fluorescent, (12) 45.8" T-5 HO lamps, (3) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 12 T5HO	PRS Elec.	12	54	690	15.5
F412GPHL /6-H	F54T5/HO	Fluorescent, (12) 45.8" T-5 HO lamps, (6) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 12-Lamp T5HO	PRS Elec.	12	54	702	15.5
F41GPRL-H	F54T5/HO-RW	Fluorescent (1) 45.2" T-5 HO reduced-wattage lamp, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 1-Lamp T5HO	PRS Elec.	1	47-51	61	15.5
F42GPRL-H	F54T5/HO-RW	Fluorescent (2) 45.2" T-5 HO reduced-wattage lamp, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 2-Lamp T5HO	PRS Elec.	2	47-51	110	15.5
F43GPRL-H	F54T5/HO-RW	Fluorescent (3) 45.2" T-5 HO reduced-wattage lamp, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 3-Lamp T5HO	PRS Elec.	3	47-51	166	15.5
F44GPRL-H	F54T5/HO-RW	Fluorescent (4) 45.2" T-5 HO reduced-wattage lamp, (1) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 4-Lamp T5HO	PRS Elec.	4	47-51	211	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F48GPRL/2-H	F54T5/HO-RW	Fluorescent, (8) 45.8" T-5 HO reduced-wattage lamps, (2) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 8-Lamp T5HO	PRS Elec.	8	50	428	15.5
F48GPRL/4-H	F54T5/HO-RW	Fluorescent, (8) 45.8" T-5 HO reduced-wattage lamps, (4) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 8-Lamp T5HO	PRS Elec.	8	50	436	15.5
F410GPRL/3-H	F54T5/HO-RW	Fluorescent, (10) 45.8" T-5 HO reduced-wattage lamps, (3) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 10L T5HO	PRS Elec.	10	50	537	15.5
F410GPRL/5-H	F54T5/HO-RW	Fluorescent, (10) 45.8" T-5 HO reduced-wattage lamps, (5) PRS Electronic Ballast, HLO (.95 < BF < 1.1)	4' 10L T5HO	PRS Elec.	10	50	545	15.5
F412GPRL/3-H	F54T5/HO-RW	Fluorescent, (12) 45.8" T-5 HO reduced-wattage lamps, (3) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 12-Lamp T5HO	PRS Elec.	12	50	642	15.5
F412GPRL/6-H	F54T5/HO-RW	Fluorescent, (12) 45.8" T-5 HO reduced-wattage lamps, (6) PRS Electronic Ballasts, HLO (.95 < BF < 1.1)	4' 12-Lamp T5HO	PRS Elec.	12	50	654	15.5
F51GPHL-H	F80T5/HO	Fluorescent (1) 57.6" (1463mm) T-5 HO lamp; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	5' 1-Lamp T5HO	PRS Elec.	1	80	90	15.5
F52GPHL/2-H	F80T5/HO	Fluorescent (2) 57.6" (1463mm) T-5 HO lamps; (1) Prog.Start or PRS Ballast, HLO (.95 < BF < 1.1)	5' 2-Lamp T5HO	PRS Elec.	2	80	180	15.5
FT8		T8 Linear Fluorescent Systems						
F1.51LS	F15T8	Fluorescent, (1) 18" T-8 lamp	1.5' 1-Lamp T8	Mag-STD	1	15	19	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F1.52LS	F15T8	Fluorescent, (2) 18" T-8 lamps	1.5' 2-Lamp T8	Mag-STD	2	15	36	15.5
F21GLL	F17T8	Fluorescent (1) 24" T-8 lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	PRS Elec.	1	17	18	15.5
F21ILL	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	18	15.5
F21ILL-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF< 0.85)	2' 1-Lamp T8 RLO	Electronic	1	17	17	15.5
F21ILL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	17	15.5
F21ILL/T2-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 2-lamp IS Ballast, RLO (BF< 0.85)	2' 1-Lamp T8 RLO	Electronic	1	17	15	15.5
F21ILL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	16	15.5
F21ILL/T3-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	2' 1-Lamp T8 RLO	Electronic	1	17	14	15.5
F21ILL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	15	15.5
F21ILL/T4-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	2' 1-Lamp T8 RLO	Electronic	1	17	13	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F21ILU	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	17	15.5
F21ILU-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF< 0.85)	2' 1-Lamp T8 RLO	Electronic	1	17	15	15.5
F21ILU-V	F17T8	Fluorescent, (1) 24", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	2' 1-Lamp T8 VHLO	Electronic	1	17	22	15.5
F21LL	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	16	15.5
F21LL-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, RLO (BF< 0.85)	2' 1-Lamp T8 RLO	Electronic	1	17	15	15.5
F21LL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 2-Lamp RS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	16	15.5
F21LL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 3-Lamp RS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	17	15.5
F21LL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Tandem 4-Lamp RS Ballast, NLO (0.85 < BF < 0.95)	2' 1-Lamp T8	Electronic	1	17	17	15.5
F21SL	F17T8	Fluorescent, (1) 24", T-8 lamp, Standard Ballast	2' 1-Lamp T8	Mag-STD	1	17	24	15.5
F22GLL	F17T8	Fluorescent (2) 24" T-8 lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	2' 2-Lamp T8	PRS Elec.	2	17	31	15.5
F22ILL	F17T8	Fluorescent, (2) 24", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 2-Lamp T8	Electronic	2	17	33	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F22ILL-R	F17T8	Fluorescent, (2) 24", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	2' 2-Lamp T8 RLO	Electronic	2	17	30	15.5
F22ILL/T4	F17T8	Fluorescent, (2) 24", T-8 lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	2' 2-Lamp T8	Electronic	2	17	30	15.5
F22ILL/T4-R	F17T8	Fluorescent, (2) 24", T-8 lamps, Tandem 4-lamp IS Ballast, RLO (BF<.85)	2' 2-Lamp T8 RLO	Electronic	2	17	27	15.5
F22ILU	F17T8	Fluorescent, (2) 24", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 2-Lamp T8	Electronic	2	17	30	15.5
F22ILU-R	F17T8	Fluorescent, (2) 24", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	2' 2-Lamp T8 RLO	Electronic	2	17	27	15.5
F22ILU-V	F17T8	Fluorescent, (2) 24", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	2' 2-Lamp T8 VHLO	Electronic	2	17	41	15.5
F22ILU/T4-R	F17T8	Fluorescent, (2) 24", T-8 lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	2' 2-Lamp T8 RLO	Electronic	2	17	26	15.5
F22LL	F17T8	Fluorescent, (2) 24", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	2' 2-Lamp T8	Electronic	2	17	31	15.5
F22LL-R	F17T8	Fluorescent, (2) 24", T-8 lamps, Rapid Start Ballast, RLO (BF< 0.85)	2' 2-Lamp T8 RLO	Electronic	2	17	28	15.5
F22LL/T4	F17T8	Fluorescent, (2) 24", T-8 lamps, Tandem 4-lamp RS Ballast, NLO (0.85 < BF < 0.95)	2' 2-Lamp T8	Electronic	2	17	34	15.5
F23GLL	F17T8	Fluorescent (3) 24" T-8 lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	2' 3-Lamp T8	PRS Elec.	3	17	47	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F23ILL	F17T8	Fluorescent, (3) 24", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 3-Lamp T8	Electronic	3	17	47	15.5
F23ILL-H	F17T8	Fluorescent, (3) 24", T-8 lamps, Instant Start Ballast, HLO (0.95 < BF < 1.1)	2' 3-Lamp T8 HLO	Electronic	3	17	51	15.5
F23ILL-R	F17T8	Fluorescent, (3) 24", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	2' 3-Lamp T8 RLO	Electronic	3	17	41	15.5
F23ILU	F17T8	Fluorescent, (3) 24", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 3-Lamp T8	Electronic	3	17	45	15.5
F23ILU-R	F17T8	Fluorescent, (3) 24", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	2' 3-Lamp T8 RLO	Electronic	3	17	40	15.5
F23ILU-V	F17T8	Fluorescent, (3) 24", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	2' 3-Lamp T8 VHLO	Electronic	3	17	59	15.5
F23LL	F17T8	Fluorescent, (3) 24", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	2' 3-Lamp T8	Electronic	3	17	52	15.5
F23LL-R	F17T8	Fluorescent, (3) 24", T-8 lamps, Rapid Start Ballast, RLO (BF< 0.85)	2' 3-Lamp T8 RLO	Electronic	3	17	41	15.5
F24GLL	F17T8	Fluorescent (4) 24" T-8 lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	2' 4-Lamp T8	PRS Elec.	4	17	59	15.5
F24ILL	F17T8	Fluorescent, (4) 24", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 4-Lamp T8	Electronic	4	17	59	15.5
F24ILL-R	F17T8	Fluorescent, (4) 24", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	2' 4-Lamp T8 RLO	Electronic	4	17	53	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F24ILU	F17T8	Fluorescent, (4) 24", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	2' 4-Lamp T8	Electronic	4	17	57	15.5
F24ILU-R	F17T8	Fluorescent, (4) 24", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	2' 4-Lamp T8 RLO	Electronic	4	17	52	15.5
F24LL	F17T8	Fluorescent, (4) 24", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	2' 4-Lamp T8	Electronic	4	17	68	15.5
F24LL-R	F17T8	Fluorescent, (4) 24", T-8 lamps, Rapid Start Ballast, RLO (BF< 0.85)	2' 4-Lamp T8 RLO	Electronic	4	17	57	15.5
F31ILL	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	26	15.5
F31ILL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	3' 1-Lamp T8 HLO	Electronic	1	25	28	15.5
F31ILL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	22	15.5
F31ILL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	23	15.5
F31ILL/T2-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 3-lamp IS Ballast, 1 lead capped, HLO (0.95 < BF < 1.1)	3' 1-Lamp T8	Electronic	1	25	26	15.5
F31ILL/T2-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 2-lamp IS Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	21	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F31ILL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	23	15.5
F31ILL/T3-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	20	15.5
F31ILL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	22	15.5
F31ILL/T4-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	20	15.5
F31ILU	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	23	15.5
F31ILU-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	20	15.5
F31ILU/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	22	15.5
F31ILU/T2-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 2-lamp IS Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	20	15.5
F31ILU/T3-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	19	15.5
F31ILU/T4-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	19	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F31LL	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	24	15.5
F31LL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, HLO (0.95 < BF < 1.1)	3' 1-Lamp T8 HLO	Electronic	1	25	26	15.5
F31LL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, RLO (BF< 0.85)	3' 1-Lamp T8 RLO	Electronic	1	25	23	15.5
F31LL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 2-lamp RS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	23	15.5
F31LL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 3-lamp RS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	24	15.5
F31LL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Tandem 4-lamp RS Ballast, NLO (0.85 < BF < 0.95)	3' 1-Lamp T8	Electronic	1	25	22	15.5
F32ILL	F25T8	Fluorescent, (2) 36", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 2-Lamp T8	Electronic	2	25	46	15.5
F32ILL-H	F25T8	Fluorescent, (2) 36", T-8 lamps, Instant Start Ballast, HLO (0.95 < BF < 1.1)	3' 2-Lamp T8 HLO	Electronic	2	25	52	15.5
F32ILL-R	F25T8	Fluorescent, (2) 36", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	3' 2-Lamp T8 RLO	Electronic	2	25	42	15.5
F32ILL/2-R	F25T8	Fluorescent, (2) 36", T-8 lamps, (2) Instant Start Ballasts, RLO (BF< 0.85)	3' 2-Lamp T8 RLO	Electronic	2	25	44	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F32ILL/T4	F25T8	Fluorescent, (2) 36", T-8 lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	3' 2-Lamp T8	Electronic	2	25	44	15.5
F32ILL/T4-R	F25T8	Fluorescent, (2) 36", T-8 lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	3' 2-Lamp T8 RLO	Electronic	2	25	39	15.5
F32ILU	F25T8	Fluorescent, (2) 36", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 2-Lamp T8	Electronic	2	25	44	15.5
F32ILU-R	F25T8	Fluorescent, (2) 36", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	3' 2-Lamp T8 RLO	Electronic	2	25	39	15.5
F32ILU/T4-R	F25T8	Fluorescent, (2) 36", T-8 lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	3' 2-Lamp T8 RLO	Electronic	2	25	39	15.5
F32LL	F25T8	Fluorescent, (2) 36", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	3' 2-Lamp T8	Electronic	2	25	46	15.5
F32LL-H	F25T8	Fluorescent, (2) 36", T-8 lamps, Rapid Start Ballast, HLO (0.95 < BF < 1.1)	3' 2-Lamp T8 HLO	Electronic	2	25	50	15.5
F32LL-R	F25T8	Fluorescent, (2) 36", T-8 lamps, Rapid Start Ballast, RLO (BF< 0.85)	3' 2-Lamp T8 RLO	Electronic	2	25	42	15.5
F32LL-V	F25T8	Fluorescent, (2) 36", T-8 lamps, Rapid Start Ballast, VHLO (BF > 1.1)	3' 2-Lamp T8 VHLO	Electronic	2	25	70	15.5
F32LL/T4	F25T8	Fluorescent, (2) 36", T-8 lamps, Tandem 4-lamp RS Ballast, NLO (0.85 < BF < 0.95)	3' 2-Lamp T8	Electronic	2	25	45	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F33ILL	F25T8	Fluorescent, (3) 36", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 3-Lamp T8	Electronic	3	25	68	15.5
F33ILL-R	F25T8	Fluorescent, (3) 36", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	3' 3-Lamp T8 RLO	Electronic	3	25	61	15.5
F33ILU	F25T8	Fluorescent, (3) 36", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 3-Lamp T8	Electronic	3	25	65	15.5
F33ILU-R	F25T8	Fluorescent, (3) 36", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	3' 3-Lamp T8 RLO	Electronic	3	25	58	15.5
F33LL	F25T8	Fluorescent, (3) 36", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	3' 3-Lamp T8	Electronic	3	25	72	15.5
F33LL-R	F25T8	Fluorescent, (3) 36", T-8 lamps, Rapid Start Ballast, RLO (BF< 0.85)	3' 3-Lamp T8 RLO	Electronic	3	25	62	15.5
F34ILL	F25T8	Fluorescent, (4) 36", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 4-Lamp T8	Electronic	4	25	88	15.5
F34ILL-R	F25T8	Fluorescent, (4) 36", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	3' 4-Lamp T8 RLO	Electronic	4	25	78	15.5
F34ILL/2-R	F25T8	Fluorescent, (4) 36", T-8 lamps, (2) Instant Start Ballasts, RLO (BF< 0.85)	3' 4-Lamp T8 RLO	Electronic	4	25	84	15.5
F34ILU	F25T8	Fluorescent, (4) 36", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	3' 4-Lamp T8	Electronic	4	25	86	15.5
F34ILU-R	F25T8	Fluorescent, (4) 36", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	3' 4-Lamp T8 RLO	Electronic	4	25	77	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F34LL	F25T8	Fluorescent, (4) 36", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	3' 4-Lamp T8	Electronic	4	25	89	15.5
F34LL-R	F25T8	Fluorescent, (4) 36", T-8 lamps, Rapid Start Ballast, RLO (BF< 0.85)	3' 4-Lamp T8 RLO	Electronic	4	25	84	15.5
F36ILL/2	F25T8	Fluorescent, (6) 36", T-8 lamps, (2) Instant Start Ballasts, NLO (0.85 < BF < 0.95)	3' 6-Lamp T8	Electronic	6	25	135	15.5
F36ILL/2-R	F25T8	Fluorescent, (6) 36", T-8 lamps, (2) Instant Start Ballasts, RLO (BF< 0.85)	3' 6-Lamp T8 RLO	Electronic	6	25	121	15.5
F42GRLL-V	F28T8	Fluorescent, (2) 48", T-8 lamps, Prog. Start or PRS Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 28W VLHO	PRS Elec.	2	28	66	15.5
F43GRLL-V	F28T8	Fluorescent, (3) 48", T-8 lamps, Prog. Start or PRS Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 28W VLHO	PRS Elec.	3	28	92	15.5
F41GLL	F32T8	Fluorescent (1) 48" T-8 lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	PRS Elec.	1	32	30	15.5
F41GLL-R	F32T8	Fluorescent (1) 48" T-8 lamp, Prog. Start or PRS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	PRS Elec.	1	32	25	15.5
F41ILL	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	31	15.5
F41ILL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	36	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F41ILL-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	27	15.5
F41ILL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	29	15.5
F41ILL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp IS Ballast, 1 lead capped, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	33	15.5
F41ILL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 2-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	26	15.5
F41ILL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	28	15.5
F41ILL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp IS Ballast, 1 lead capped, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	31	15.5
F41ILL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	25	15.5
F41ILL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	28	15.5
F41ILL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	25	15.5
F41ILU	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	28	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F41ILU-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	35	15.5
F41ILU-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	25	15.5
F41ILU/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	27	15.5
F41ILU/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 2-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	24	15.5
F41ILU/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	27	15.5
F41ILU/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	24	15.5
F41ILU/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	27	15.5
F41ILU/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	24	15.5
F41LE	F32T8	Fluorescent, (1) 48", T-8 lamp	4' 1-Lamp T8	Mag-ES	1	32	35	15.5
F41LL	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	32	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F41LL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	39	15.5
F41LL-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	27	15.5
F41LL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 2-lamp RS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	30	15.5
F41LL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp RS Ballast, 1 lead capped, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	35	15.5
F41LL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 2-lamp RS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	27	15.5
F41LL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp RS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	31	15.5
F41LL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp RS Ballast, 1 lead capped, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 HLO	Electronic	1	32	33	15.5
F41LL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 3-lamp RS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	25	15.5
F41LL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp RS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8	Electronic	1	32	30	15.5
F41LL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Tandem 4-lamp RS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 RLO	Electronic	1	32	26	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42GLL	F32T8	Fluorescent (2) 48" T-8 lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	PRS Elec.	2	32	59	15.5
F42GLL-R	F32T8	Fluorescent (2) 48" T-8 lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 2-Lamp T8 RLO	PRS Elec.	2	32	47	15.5
F42GLL-V	F32T8	Fluorescent, (2) 48" T-8 lamps, Prog. Start or PRS Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 VHLO	PRS Elec.	2	32	74	15.5
F42ILL	F32T8	Fluorescent, (2) 48", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	58	15.5
F42ILL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 2-Lamp T8 HLO	Electronic	2	32	66	15.5
F42ILL-R	F32T8	Fluorescent, (2) 48", T-8 lamps, Instant Start Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	51	15.5
F42ILL-V	F32T8	Fluorescent, (2) 48", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 VHLO	Electronic	2	32	77	15.5
F42ILL/2	F32T8	Fluorescent, (2) 48", T-8 lamps, (2) 1-lamp Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	62	15.5
F42ILL/2-R	F32T8	Fluorescent, (2) 48" T-8 lamps, (2) 1-lamp Instant Start Ballasts, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	54	15.5
F42ILL/T4	F32T8	Fluorescent, (2) 48", T-8 lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	56	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42ILL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	49	15.5
F42ILU	F32T8	Fluorescent, (2) 48", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	54	15.5
F42ILU-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 2-Lamp T8 HLO	Electronic	2	32	64	15.5
F42ILU-R	F32T8	Fluorescent, (2) 48", T-8 lamps, Instant Start, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	48	15.5
F42ILU-V	F32T8	Fluorescent, (2) 48", T-8 lamps, Instant Start, VHLO (BF> 1.1)	4' 2-Lamp T8 VHLO	Electronic	2	32	73	15.5
F42ILU/T4	F32T8	Fluorescent, (2) 48", T-8 lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	54	15.5
F42ILU/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	48	15.5
F42LE	F32T8	Fluorescent, (2) 48", T-8 lamp	4' 2-Lamp T8	Mag-ES	2	32	71	15.5
F42LL	F32T8	Fluorescent, (2) 48", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	60	15.5
F42LL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, HLO (0.95 < BF < 1.1)	4' 2-Lamp T8 HLO	Electronic	2	32	70	15.5
F42LL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	54	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42LL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 HLO	Electronic	2	32	85	15.5
F42LL/2	F32T8	Fluorescent, (2) 48", T-8 lamps, (2) 1-lamp Rapid Start Ballasts, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	64	15.5
F42LL/T4	F32T8	Fluorescent, (2) 48", T-8 lamps, Tandem 4-lamp RS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8	Electronic	2	32	59	15.5
F42LL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Tandem 4-lamp RS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 RLO	Electronic	2	32	53	15.5
F43GLL	F32T8	Fluorescent (3) 48" T-8 lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8	PRS Elec.	3	32	88	15.5
F43GLL-R	F32T8	Fluorescent (3) 48" T-8 lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 RLO	PRS Elec.	3	32	72	15.5
F43GLL-V	F32T8	Fluorescent, (3) 48" T-8 lamps, Prog. Start or PRS Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 VHLO	Electronic	3	32	108	15.5
F43ILL	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8	Electronic	3	32	85	15.5
F43ILL-H	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 3-Lamp T8 HLO	Electronic	3	32	93	15.5
F43ILL-R	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 RLO	Electronic	3	32	76	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F43ILL-V	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 VHLO	Electronic	3	32	112	15.5
F43ILL/2	F32T8	Fluorescent, (3) 48" T-8 lamps, (2) Instant Start Ballasts, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8	Electronic	3	32	89	15.5
F43ILL/2-H	F32T8	Fluorescent (3) 48" T-8 lamps, (1) 2-lamp and (1) 3-lamp IS Ballast,1 lead capped, HLO (0.95 < BF < 1.1)	4' 3-Lamp T8 HLO	Electronic	3	32	102	15.5
F43ILL/2-R	F32T8	Fluorescent, (3) 48" T-8 lamps, (1) 1-lamp and (1) 2-lamp IS Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 RLO	Electronic	3	32	78	15.5
F43ILU	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8	Electronic	3	32	81	15.5
F43ILU-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 3-Lamp T8 HLO	Electronic	3	32	92	15.5
F43ILU-R	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 RLO	Electronic	3	32	72	15.5
F43ILU-V	F32T8	Fluorescent, (3) 48" T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 VHLO	Electronic	3	32	108	15.5
F43LE	F32T8	Fluorescent, (3) 48", T-8 lamp	4' 3-Lamp T8	Mag-ES	3	32	110	15.5
F43LL	F32T8	Fluorescent, (3) 48", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8	Electronic	3	32	93	15.5
F43LL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, HLO (.95 < BF < 1.1)	4' 3-Lamp T8 HLO	Electronic	3	32	98	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F43LL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 RLO	Electronic	3	32	76	15.5
F43LL/2	F32T8	Fluorescent, (3) 48", T-8 lamps, (1) 1-lamp and (1) 2-lamp RS Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8	Electronic	3	32	92	15.5
F44GLL	F32T8	Fluorescent (4) 48" T-8 lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8	PRS Elec.	4	32	115	15.5
F44GLL-R	F32T8	Fluorescent (4) 48" T-8 lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 RLO	PRS Elec.	4	32	92	15.5
F44GLL-V	F32T8	Fluorescent, (4) 48" T-8 lamps, Prog. Start or PRS Ballast, VHLO (BF > 1.1)	4' 4-Lamp T8 VHLO	PRS Elec.	4	32	144	15.5
F44ILL	F32T8	Fluorescent, (4) 48", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8	Electronic	4	32	112	15.5
F44ILL-R	F32T8	Fluorescent, (4) 48", T-8 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 RLO	Electronic	4	32	98	15.5
F44ILL-V	F32T8	Fluorescent, (4) 48", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 4-Lamp T8 VHLO	Electronic	4	32	151	15.5
F44ILL/2	F32T8	Fluorescent, (4) 48", T-8 lamps, (2) 2-lamp IS Ballasts, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8	Electronic	4	32	116	15.5
F44ILL/2-H	F32T8	Fluorescent, (4) 48", T-8 lamps, (2) 3-lamp IS Ballasts, 1 lead capped, HLO (.95 < BF < 1.1)	4' 4-Lamp T8 HLO	Electronic	4	32	132	15.5
F44ILL/2-R	F32T8	Fluorescent, (4) 48", T-8 lamps, (2) 2-lamp IS Ballasts, RLO (BF < 0.85)	4' 4-Lamp T8 RLO	Electronic	4	32	102	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F44ILL/2-V	F32T8	Fluorescent, (4) 48", T-8 lamps, (2) 2-lamp IS Ballasts, VHLO (BF > 1.1)	4' 4-Lamp T8 VHLO	Electronic	4	32	154	15.5
F44ILU	F32T8	Fluorescent, (4) 48", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8	Electronic	4	32	107	15.5
F44ILU-H	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 4-Lamp T8 HLO	Electronic	4	32	121	15.5
F44ILU-R	F32T8	Fluorescent, (4) 48", T-8 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 RLO	Electronic	4	32	95	15.5
F44ILU-V	F32T8	Fluorescent, (4) 48", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 4-Lamp T8 VHLO	Electronic	4	32	146	15.5
F44LE	F32T8	Fluorescent, (4) 48", T-8 lamps	4' 4-Lamp T8	Mag-ES	4	32	142	15.5
F44LL	F32T8	Fluorescent, (4) 48", T-8 lamps, Rapid Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8	Electronic	4	32	118	15.5
F44LL-R	F32T8	Fluorescent, (4) 48", T-8 lamps, Rapid Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 RLO	Electronic	4	32	105	15.5
F44LL/2	F32T8	Fluorescent, (4) 48", T-8 lamps, (2) 2-lamp Rapid Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8	Electronic	4	32	120	15.5
F45ILL/2	F32T8	Fluorescent, (5) 48", T-8 lamps, (1) 3-lamp and (1) 2-lamp IS ballast, NLO (0.85 < BF < 0.95)	4' 5-Lamp T8	Electronic	5	32	143	15.5
F45GLL/2-V	F32T8	Fluorescent, (5) 48", T-8 lamps, (1) 3-lamp and (1) 2-lamp Prog. Start Ballast, VHLO (BF > 1.1)	4' 5-Lamp T8 VHLO	Electronic	5	32	182	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F46GLL/2	F32T8	Fluorescent (6) 48" T-8 lamps, (2) Prog. Start or PRS Ballasts, NLO (0.85 < BF < 0.95)	4' 6-Lamp T8	PRS Elec.	6	32	175	15.5
F46GLL/2-R	F32T8	Fluorescent (6) 48" T-8 lamps, (2) Prog. Start or PRS Ballasts, RLO (BF < 0.85)	4' 6-Lamp T8 RLO	PRS Elec.	6	32	142	15.5
F46GLL/2-V	F32T8	Fluorescent (6) 48" T-8 lamps, (2) Prog. Start or PRS Ballasts, VHLO (BF > 1.1)	4' 6-Lamp T8 VHLO	PRS Elec.	6	32	217	15.5
F46ILL/2	F32T8	Fluorescent, (6) 48", T-8 lamps, (2) IS Ballasts, NLO (0.85 < BF < 0.95)	4' 6-Lamp T8	Electronic	6	32	170	15.5
F46ILL/2-R	F32T8	Fluorescent, (6) 48", T-8 lamps, (2) IS Ballasts, RLO (BF < 0.85)	4' 6-Lamp T8 RLO	Electronic	6	32	151	15.5
F46ILL/2-V	F32T8	Fluorescent (6) 48" T-8 lamps, (2) IS Ballasts, VHLO (BF > 1.1)	4' 6-Lamp T8 VHLO	Electronic	6	32	226	15.5
F46ILU/2	F32T8	Fluorescent (6) 48" T-8 lamps, (2) IS Ballasts, NLO (0.85 < BF < 0.95)	4' 6-Lamp T8	Electronic	6	32	162	15.5
F46ILU/2-R	F32T8	Fluorescent (6) 48" T-8 lamps, (2) IS Ballasts, RLO (BF < 0.85)	4' 6-Lamp T8 RLO	Electronic	6	32	144	15.5
F46ILU/2-V	F32T8	Fluorescent (6) 48" T-8 lamps, (2) IS Ballasts, VHLO (BF > 1.1)	4' 6-Lamp T8 VHLO	Electronic	6	32	218	15.5
F465LL/2	F32T8	Fluorescent, (6) 48", T-8 lamps, (2) Rapid Start Ballasts, NLO (0.85 < BF < 0.95)	4' 6-Lamp T8	Electronic	6	32	182	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F48GLL/2	F32T8	Fluorescent (8) 48" T-8 lamps, (2) Prog. Start or PRS Ballasts, NLO (0.85 < BF < 0.95)	4' 8-Lamp T8	PRS Elec.	8	32	230	15.5
F48GLL/2-R	F32T8	Fluorescent (8) 48" T-8 lamps, (2) Prog. Start or PRS Ballasts, RLO (BF < 0.85)	4' 8-Lamp T8 RLO	PRS Elec.	8	32	184	15.5
F48GLL/2-V	F32T8	Fluorescent (8) 48" T-8 lamps, (2) Prog. Start or PRS Ballasts, VHLO (BF > 1.1)	4' 8-Lamp T8 VHLO	PRS Elec.	8	32	288	15.5
F48ILL/2	F32T8	Fluorescent, (8) 48", T-8 lamps, (2) 4-lamp IS Ballasts, NLO (0.85 < BF < 0.95)	4' 8-Lamp T8	Electronic	8	32	224	15.5
F48ILL/2-R	F32T8	Fluorescent, (8) 48", T-8 lamps, (2) 4-lamp IS Ballasts, RLO (BF < 0.85)	4' 8-Lamp T8 RLO	Electronic	8	32	196	15.5
F48ILU/2	F32T8	Fluorescent, (8) 48", T-8 lamps, (2) 4-lamp IS Ballasts, NLO (0.85 < BF < 0.95)	4' 8-Lamp T8	Electronic	8	32	214	15.5
F48ILU/2-R	F32T8	Fluorescent, (8) 48", T-8 lamps, (2) 4-lamp IS Ballasts, RLO (BF < 0.85)	4' 8-Lamp T8 RLO	Electronic	8	32	190	15.5
F48ILU/2-V	F32T8	Fluorescent, (8) 48", T-8 lamps, (2) 4-lamp IS Ballasts, VHLO (BF > 1.1)	4' 8-Lamp T8 VHLO	Electronic	8	32	292	15.5
F41GNLL	F32T8-25W	Fluorescent (1) 48" T-8 @ 25W lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 25W	PRS Elec.	1	25	24	15.5
F41GNLL-R	F32T8-25W	Fluorescent (1) 48" T-8 @ 25W lamp, Prog. Start or PRS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 25W RLO	PRS Elec.	1	25	21	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F41INLL	F32T8-25W	Fluorescent, (1) 48", T-8 @ 25W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 25W	Electronic	1	25	24	15.5
F41INLU	F32T8-25W	Fluorescent, (1), T-8 @ 25W lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 25W	Electronic	1	25	23	15.5
F41INLU-R	F32T8-25W	Fluorescent, (1), T-8 @ 25W lamp, Instant Start Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 25W RLO	Electronic	1	25	21	15.5
F41INLU-V	F32T8-25W	Fluorescent, (1), T-8 @ 25W lamp, Instant Start Ballast, VHLO (BF > 1.1)	4' 1-Lamp T8 25W VHLO	Electronic	1	25	32	15.5
F41INLU/T3-R	F32T8-25W	Fluorescent, (1) 48", T-8 @ 25W lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 25W RLO	Electronic	1	25	19	15.5
F41INLU/T4-R	F32T8-25W	Fluorescent, (1) 48", T-8 @ 25W lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 25W RLO	Electronic	1	25	19	15.5
F42GNLL	F32T8-25W	Fluorescent (2) 48" T-8 @ 25W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 25W	PRS Elec.	2	25	44	15.5
F42GNLL-R	F32T8-25W	Fluorescent (2) 48" T-8 @ 25W lamps, Prog. Start or PRS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 25W RLO	PRS Elec.	2	25	38	15.5
F42INLL	F32T8-25W	Fluorescent, (2) 48", T-8 @ 25W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 25W	Electronic	2	25	46	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42INLL-V	F32T8-25W	Fluorescent, (2) 48" T-8 @ 25W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 25W VHLO	Electronic	2	25	65	15.5
F42INLU	F32T8-25W	Fluorescent, (2), T-8 @ 25W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 25W	Electronic	2	25	43	15.5
F42INLU-R	F32T8-25W	Fluorescent (2) 48" T8 @ 25W lamps, Instant Start Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 25W RLO	Electronic	2	25	38	15.5
F42INLU-V	F32T8-25W	Fluorescent, (2) 48", T-8 @ 25W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 25W VHLO	Electronic	2	25	60	15.5
F42INLU/T 4-R	F32T8-25W	Fluorescent, (2) 48", T-8 @ 25W lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 25W RLO	Electronic	2	25	38	15.5
F43GNLL	F32T8-25W	Fluorescent (3) 48" T-8 @ 25W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 25W	PRS Elec.	3	25	66	15.5
F43GNLL-R	F32T8-25W	Fluorescent, (3) 48" T-8 @ 25W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 25W RLO	PRS Elec.	3	25	56	15.5
F43INLL	F32T8-25W	Fluorescent, (3) 48" T-8 @ 25W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 25W	Electronic	3	25	66	15.5
F43INLL-V	F32T8-25W	Fluorescent, (3) 48" T-8 @ 25W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 25W VHLO	Electronic	3	25	95	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F43INLU	F32T8-25W	Fluorescent, (3) 48" T-8 lamps @ 25W, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 25W	Electronic	3	25	64	15.5
F43INLU-R	F32T8-25W	Fluorescent, (3) 48" T-8 @ 25W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 25W RLO	Electronic	3	25	57	15.5
F43INLU-V	F32T8-25W	Fluorescent, (3) 48" T-8 @ 25W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 25W VHLO	Electronic	3	25	93	15.5
F44GNLL	F32T8-25W	Fluorescent (4) 48" T-8 @ 25W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 25W	PRS Elec.	4	25	85	15.5
F44GNLL-R	F32T8-25W	Fluorescent (4) 48" T-8 @ 25W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 25W RLO	PRS Elec.	4	25	73	15.5
F44INLL	F32T8-25W	Fluorescent, (4) 48", T-8 @ 25W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 25W	Electronic	4	25	86	15.5
F44INLU	F32T8-25W	Fluorescent, (4) 48", T-8 @ 25W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 25W	Electronic	4	25	85	15.5
F44INLU-R	F32T8-25W	Fluorescent, (4) 48" T-8 @ 25W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 25W RLO	Electronic	4	25	75	15.5
F44INLU-V	F32T8-25W	Fluorescent, (4) 48" T-8 @ 25W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 4-Lamp T8 25W VHLO	Electronic	4	25	122	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F46INLU/ 2-R	F32T8-25W	Fluorescent (6) 48" T-8 @ 25W lamps, (2) IS Ballasts, RLO (BF < 0.85)	4' 6-Lamp T8 25W RLO	Electronic	6	25	114	15.5
F46INLU/ 2-V	F32T8-25W	Fluorescent (6) 48" T-8 @ 25W lamps, (2) IS Ballasts, VHLO (BF > 1.1)	4' 6-Lamp T8 25W VHLO	Electronic	6	25	184	15.5
F41GRLL	F32T8-28W	Fluorescent (1) 48" T-8 @ 28W lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 28W	PRS Elec.	1	28	26	15.5
F41GRLL-R	F32T8-28W	Fluorescent (1) 48" T-8 @ 28W lamp, Prog. Start or PRS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 28W RLO	PRS Elec.	1	28	22	15.5
F41IRLL	F32T8-28W	Fluorescent, (1) 48" T-8 @ 28W lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 28W	Electronic	1	28	27	15.5
F41IRLL-V	F32T8-28W	Fluorescent, (1) 48" T-8 @ 28W lamp, Instant Start Ballast, VHLO (BF > 1.1)	4' 1-Lamp T8 28W VHLO	Electronic	1	28	35	15.5
F41IRLU	F32T8-28W	Fluorescent, (1), T-8 @ 28W lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 28W	Electronic	1	28	25	15.5
F41IRLU-R	F32T8-28W	Fluorescent, (1), T-8 @ 28W lamp, Instant Start Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 28W RLO	Electronic	1	28	22	15.5
F41IRLU-V	F32T8-28W	Fluorescent, (1), T-8 @ 28W lamp, Instant Start Ballast, VHLO (BF > 1.1)	4' 1-Lamp T8 28W VHLO	Electronic	1	28	33	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F41IRLU/T 3-R	F32T8-28W	Fluorescent, (1) 48", T-8 @ 28W lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 28W RLO	Electronic	1	28	21	15.5
F41IRLU/T 4-R	F32T8-28W	Fluorescent, (1) 48", T-8 @ 28W lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 28W RLO	Electronic	1	28	21	15.5
F42GRLL	F32T8-28W	Fluorescent (2) 48" T-8 @ 28W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 28W	PRS Elec.	2	28	49	15.5
F42GRLL-R	F32T8-28W	Fluorescent (2) 48" T-8 @ 28W lamps, Prog. Start or PRS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 28W RLO	PRS Elec.	2	28	40	15.5
F42IRLL	F32T8-28W	Fluorescent, (2) 48", T-8 @ 28W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 28W NLO	Electronic	2	28	52	15.5
F42IRLL-V	F32T8-28W	Fluorescent, (2) 48" T-8 @ 28W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 28W VHLO	Electronic	2	28	68	15.5
F42IRLU	F32T8-28W	Fluorescent, (2), T-8 @ 28W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 28W	Electronic	2	28	48	15.5
F42IRLU-R	F32T8-28W	Fluorescent, (2) 48", T-8 @ 28W lamps, Instant Start Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 28W RLO	Electronic	2	28	43	15.5
F42IRLU-V	F32T8-28W	Fluorescent, (2) 48", T-8 @ 28W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 2-Lamp T8 28W VHLO	Electronic	2	28	65	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42IRLU/T 4-R	F32T8-28W	Fluorescent, (2) 48", T-8 @ 28W lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 28W RLO	Electronic	2	28	42	15.5
F43GRLL	F32T8-28W	Fluorescent (3) 48" T-8 @ 28W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 28W	PRS Elec.	3	28	75	15.5
F43GRLL-R	F32T8-28W	Fluorescent, (3) 48" T-8 @ 28W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 28W RLO	PRS Elec.	3	28	62	15.5
F43IRLL	F32T8-28W	Fluorescent, (3) 48" T-8 @ 28W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 28W	Electronic	3	28	76	15.5
F43IRLL-H	F32T8-28W	Fluorescent, (3) 48" T-8 @ 28W lamps, Instant Start Ballast, HLO (.95 < BF < 1.1)	4' 3-Lamp T8 28W HLO	Electronic	3	28	82	15.5
F43IRLL-V	F32T8-28W	Fluorescent, (3) 48" T-8 @ 28W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 28W VHLO	Electronic	3	28	97	15.5
F43IRLU	F32T8-28W	Fluorescent, (3) 48" T-8 lamps @ 28W, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 28W	Electronic	3	28	72	15.5
F43IRLU-R	F32T8-28W	Fluorescent, (3) 48" T-8 @ 28W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 28W RLO	Electronic	3	28	63	15.5
F43IRLU-V	F32T8-28W	Fluorescent, (3) 48" T-8 @ 28W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 28W VHLO	Electronic	3	28	96	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F44GRLL	F32T8-28W	Fluorescent (4) 48" T-8 @ 28W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 28W	PRS Elec.	4	28	99	15.5
F44GRLL-R	F32T8-28W	Fluorescent (4) 48" T-8 @ 28W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 28W RLO	PRS Elec.	4	28	80	15.5
F44IRLL	F32T8-28W	Fluorescent, (4) 48", T-8 @ 28W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 28W	Electronic	4	28	99	15.5
F44IRLL-R	F32T8-28W	Fluorescent, (4) 48", T-8 @ 28W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 28W RLO	Electronic	4	28	85	15.5
F44IRLU	F32T8-28W	Fluorescent, (4) 48", T-8 @ 28W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 28W	Electronic	4	28	94	15.5
F44IRLU-R	F32T8-28W	Fluorescent, (4) 48" T-8 @ 28W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 28W RLO	Electronic	4	28	83	15.5
F44IRLU-V	F32T8-28W	Fluorescent, (4) 48" T-8 @ 28W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 4-Lamp T8 28W VHLO	Electronic	4	28	131	15.5
F46IRLU/2-R	F32T8-28W	Fluorescent (6) 48" T-8 @ 28W lamps, (2) IS Ballasts, RLO (BF < 0.85)	4' 6-Lamp T8 28W	Electronic	6	28	126	15.5
F46IRLU/2-V	F32T8-28W	Fluorescent (6) 48" T-8 @ 28W lamps, (2) IS Ballasts, VHLO (BF > 1.1)	4' 6-Lamp T8 28W VHLO	Electronic	6	28	194	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F48IRLU/2-V	F32T8-28W	Fluorescent (8) 48" T-8 @ 28W lamps, (2) IS Ballasts, VHLO (BF > 1.1)	4' 6-Lamp T8 28W VHLO	Electronic	8	28	250	15.5
F41GELL	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	PRS Elec.	1	30	28	15.5
F41GELL-R	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 1-Lamp T8 30W RLO	PRS Elec.	1	30	24	15.5
F41IELL	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	29	15.5
F41IELL-H	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 30W HLO	Electronic	1	30	34	15.5
F41IELL-R	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Instant Start Ballast, RLO (BF < 0.85)	4' 1-Lamp T8 30W RLO	Electronic	1	30	26	15.5
F41IELL/T2	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	28	15.5
F41IELL/T3	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	27	15.5
F41IELL/T4	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	27	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F41IELU	F32T8-30W	Fluorescent, (1) 48", T-8 @ 30W lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	27	15.5
F41IELU-H	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 1-Lamp T8 30W HLO	Electronic	1	30	32	15.5
F41IELU-R	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Instant Start Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 30W RLO	Electronic	1	30	24	15.5
F41IELU/T 2	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	26	15.5
F41IELU/T 2-R	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 2-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 30W RLO	Electronic	1	30	23	15.5
F41IELU/T 3	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	26	15.5
F41IELU/T 3-R	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 3-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 30W RLO	Electronic	1	30	23	15.5
F41IELU/T 4	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 30W	Electronic	1	30	25	15.5
F41IELU/T 4-R	F32T8-30W	Fluorescent (1) 48" T-8 @ 30W lamp, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 1-Lamp T8 30W RLO	Electronic	1	30	22	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42GELL	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 30W	PRS Elec.	2	30	56	15.5
F42GELL-R	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 2-Lamp T8 30W RLO	PRS Elec.	2	30	43	15.5
F42IELL	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 30W	Electronic	2	30	55	15.5
F42IELL-H	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 2-Lamp T8 30W HLO	Electronic	2	30	62	15.5
F42IELL-R	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Instant Start Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 30W RLO	Electronic	2	30	49	15.5
F42IELL/T 4	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 30W	Electronic	2	30	53	15.5
F42IELL/T 4-R	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 30W RLO	Electronic	2	30	46	15.5
F42IELU	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 30W	Electronic	2	30	52	15.5
F42IELU-R	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Instant Start, RLO (BF< 0.85)	4' 2-Lamp T8 30W RLO	Electronic	2	30	45	15.5
F42IELU-V	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Instant Start, VHLO (BF > 1.1)	4' 2-Lamp T8 30W HLO	Electronic	2	30	70	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42IELU/T 4	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 30W	Electronic	2	30	51	15.5
F42IELU/T 4-R	F32T8-30W	Fluorescent (2) 48" T-8 @ 30W lamps, Tandem 4-lamp IS Ballast, RLO (BF< 0.85)	4' 2-Lamp T8 30W RLO	Electronic	2	30	45	15.5
F43GELL	F32T8-30W	Fluorescent (3) 48" T-8 @ 30W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 30W	PRS Elec.	3	30	83	15.5
F43GELL-R	F32T8-30W	Fluorescent (3) 48" T-8 @ 30W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 30W RLO	PRS Elec.	3	30	67	15.5
F43IELL	F32T8-30W	Fluorescent (3) 48" T-8 @ 30 W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 30W	Electronic	3	30	81	15.5
F43IELL-H	F32T8-30W	Fluorescent (3) 48" T-8 @ 30 W lamps, Instant Start Ballast, HLO (0.95 < BF < 1.1)	4' 3-Lamp T8 30W HLO	Electronic	3	30	86	15.5
F43IELL-R	F32T8-30W	Fluorescent (3) 48" T-8 @ 30 W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 30W RLO	Electronic	3	30	71	15.5
F43IELL/2	F32T8-30W	Fluorescent (3) 48" T-8 @ 30 W lamps, (1) 1-lamp and (1) 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 30W	Electronic	3	30	84	15.5
F43IELL/2-H	F32T8-30W	Fluorescent (3) 48" T-8 @ 30 W lamps, (1) 2-lamp, (1) 3-lamp IS Ballast, 1 lead capped, HLO (0.95 < BF < 1.1)	4' 3-Lamp T8 30W HLO	Electronic	3	30	96	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F43IELL/2-R	F32T8-30W	Fluorescent (3) 48" T-8 @ 30 W lamps, (1) 1-lamp and (1) 2-lamp IS Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 30W RLO	Electronic	3	30	75	15.5
F43IELU	F32T8-30W	Fluorescent (3) 48" T-8 @ 30W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 30W	Electronic	3	30	77	15.5
F43IELU-R	F32T8-30W	Fluorescent (3) 48" T-8 @ 30W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T8 30W RLO	Electronic	3	30	68	15.5
F43IELU-V	F32T8-30W	Fluorescent (3) 48" T-8 @ 30W lamps, Instant Start Ballast, VHLO (BF > 1.1)	4' 3-Lamp T8 30W VHLO	Electronic	3	30	104	15.5
F44GELL	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Prog. Start or PRS Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 30W	PRS Elec.	4	30	109	15.5
F44GELL-R	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Prog. Start or PRS Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 30W RLO	PRS Elec.	4	30	86	15.5
F44IELL	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 30W	Electronic	4	30	106	15.5
F44IELL-R	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 30W RLO	Electronic	4	30	92	15.5
F44IELL/2	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, (2) 2-lamp IS Ballasts, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 30W	Electronic	4	30	110	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F44IELL/2-H	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, (2) 3-lamp IS Ballasts, 1 lead capped, HLO (.95 < BF < 1.1)	4' 4-Lamp T8 30W HLO	Electronic	4	30	124	15.5
F44IELL/2-R	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, (2) 2-lamp IS Ballasts, RLO (BF< 0.85)	4' 4-Lamp T8 30W RLO	Electronic	4	30	98	15.5
F44IELU	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 30W	Electronic	4	30	101	15.5
F44IELU-R	F32T8-30W	Fluorescent (4) 48" T-8 @ 30W lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T8 30W RLO	Electronic	4	30	89	15.5
F46IELU/2	F32T8-30W	Fluorescent (6) 48" T-8 @ 30W lamps, (2) IS Ballasts, NLO (0.85 < BF < 0.95)	4' 6-Lamp T8 30W	Electronic	6	30	154	15.5
F46IELU/2-R	F32T8-30W	Fluorescent (6) 48" T-8 @ 30W lamps, (2) IS Ballasts, RLO (BF < 0.85)	4' 6-Lamp T8 30W RLO	Electronic	6	30	135	15.5
F51ILL	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	5' 1-Lamp T8	Electronic	1	40	36	15.5
F51ILL-R	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, RLO (BF < 0.85)	5' 1-Lamp T8 RLO	Electronic	1	40	43	15.5
F51ILL/T2	F40T8	Fluorescent, (1) 60", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	5' 1-Lamp T8	Electronic	1	40	36	15.5
F51ILL/T3	F40T8	Fluorescent, (1) 60", T-8 lamp, Tandem 3-lamp IS Ballast, NLO (0.85 < BF < 0.95)	5' 1-Lamp T8	Electronic	1	40	35	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F51ILL/T4	F40T8	Fluorescent, (1) 60", T-8 lamp, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	5' 1-Lamp T8	Electronic	1	40	34	15.5
F52ILL	F40T8	Fluorescent, (2) 60", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	5' 2-Lamp T8	Electronic	2	40	72	15.5
F52ILL-H	F40T8	Fluorescent, (2) 60", T-8 lamps, Instant Start Ballast, HILO (.95 < BF < 1.1)	5' 2-Lamp T8 HLO	Electronic	2	40	80	15.5
F52ILL-R	F40T8	Fluorescent, (2) 60", T-8 lamps, Instant Start Ballast, RLO (BF < 0.85)	5' 2-Lamp T8 RLO	Electronic	2	40	73	15.5
F52ILL/T4	F40T8	Fluorescent, (2) 60", T-8 lamps, Tandem 4-lamp IS Ballast, NLO (0.85 < BF < 0.95)	5' 2-Lamp T8	Electronic	2	40	67	15.5
F53ILL	F40T8	Fluorescent, (3) 60", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	5' 3-Lamp T8	Electronic	3	40	106	15.5
F53ILL-H	F40T8	Fluorescent, (3) 60", T-8 lamps, Instant Start Ballast, HILO (.95 < BF < 1.1)	5' 3-Lamp T8 HLO	Electronic	3	40	108	15.5
F54ILL	F40T8	Fluorescent, (4) 60", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	5' 4-Lamp T8	Electronic	4	40	134	15.5
F54ILL-H	F40T8	Fluorescent, (4) 60", T-8 lamps, Instant Start Ballast, HLO (.95 < BF < 1.1)	5' 4-Lamp T8 HLO	Electronic	4	40	126	15.5
F41LHL	F48T8/HO	Fluorescent, (1) 48", T-8 HO lamps, (1) Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 1-Lamp T8 44W HO	Electronic	1	44	59	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F42LHL	F48T8/HO	Fluorescent, (2) 48", T-8 HO lamps, (1) Instant Start Ballast, NLO (0.85 < BF < 0.95)	4' 2-Lamp T8 44W HO	Electronic	2	44	98	15.5
F43LHL	F48T8/HO	Fluorescent, (3) 48", T-8 HO lamps, (2) Instant Start Ballasts, NLO (0.85 < BF < 0.95)	4' 3-Lamp T8 44W HO	Electronic	3	44	141	15.5
F44LHL	F48T8/HO	Fluorescent, (4) 48", T-8 HO lamps, (2) Instant Start Ballasts, NLO (0.85 < BF < 0.95)	4' 4-Lamp T8 44W HO	Electronic	4	44	168	15.5
F81ILL	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 1-Lamp T8	Electronic	1	59	69	15.5
F81ILL-H	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, HILO (.95 < BF < 1.1)	8' 1-Lamp T8 HLO	Electronic	1	59	70	15.5
F81ILL-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF < 0.85)	8' 1-Lamp T8 RLO	Electronic	1	59	67	15.5
F81ILL-V	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, VHLO (BF > 1.1)	8' 1-Lamp T8 VHLO	Electronic	1	59	72	15.5
F81ILL/T2	F96T8	Fluorescent, (1) 96", T-8 lamp, Tandem 2-lamp IS Ballast, NLO (0.85 < BF < 0.95)	8' 1-Lamp T8	Electronic	1	59	55	15.5
F81ILL/T2-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Tandem 2-lamp IS Ballast, RLO (BF < 0.85)	8' 1-Lamp T8 RLO	Electronic	1	59	50	15.5
F81ILU	F96T8	Fluorescent, (1) 96" T-8 lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 1-Lamp T8	Electronic	1	59	67	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F82ILL	F96T8	Fluorescent, (2) 96", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 2-Lamp T8	Electronic	2	59	110	15.5
F82ILL-R	F96T8	Fluorescent, (2) 96", T-8 lamps, Instant Start Ballast, RLO (BF < 0.85)	8' 2-Lamp T8 RLO	Electronic	2	59	100	15.5
F82ILL-V	F96T8	Fluorescent, (2) 96", T-8 lamps, Instant Start Ballast, VHLO (BF > 1.1)	8' 2-Lamp T8 VHLO	Electronic	2	59	149	15.5
F82ILU	F96T8	Fluorescent, (2) 96" T-8 ES lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 2-Lamp T8	Electronic	2	59	107	15.5
F83ILL	F96T8	Fluorescent, (3) 96", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 3-Lamp T8	Electronic	3	59	179	15.5
F84ILL	F96T8	Fluorescent, (4) 96", T-8 lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 4-Lamp T8	Electronic	4	59	219	15.5
F84ILL/2-V	F96T8	Fluorescent, (4) 96", T-8 lamps, (2) Instant Start Ballasts, VHLO (BF > 1.1)	8' 4-Lamp T8 VHLO	Electronic	4	59	298	15.5
F86ILL	F96T8	Fluorescent, (6) 96", T-8 lamps, (2) 3-lamp IS Ballasts, NLO (0.85 < BF < 0.95)	8' 6-Lamp T8	Electronic	6	59	330	15.5
F81LHL/T2	F96T8/HO	Fluorescent, (1) 96", T-8 HO lamp, Tandem 2-lamp Ballast	8' 1-Lamp T8 86W HO	Electronic	1	86	80	15.5
F82LHL	F96T8/HO	Fluorescent, (2) 96", T-8 HO lamps	8' 2-Lamp T8 86W HO	Electronic	2	86	160	15.5
F84LHL	F96T8/HO	Fluorescent, (4) 96", T-8 HO lamps	8' 4-Lamp T8 86W HO	Electronic	4	86	320	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F81IERU	F96T8-RW	Fluorescent, (1) 96" T-8 reduced-wattage lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 1-Lamp T8 54W	Electronic	1	54	61	15.5
F82IERU	F96T8-RW	Fluorescent, (2) 96" T-8 @ reduced-wattage lamps, Instant Start Ballast, NLO (0.85 < BF < 0.95)	8' 2-Lamp T8 54W	Electronic	2	54	93	15.5
FT12		T12 and Other Linear Fluorescent Systems						
F1.51SS	F15T12	Fluorescent, (1) 18" T12 lamp	1.5' 1-Lamp T12 15W	Mag-STD	1	15	19	8.5
F1.52SS	F15T12	Fluorescent, (2) 18", T12 lamps	1.5' 2-Lamp T12 15W	Mag-STD	2	15	36	8.5
F21SS	F20T12	Fluorescent, (1) 24", STD lamp	2' 1-Lamp T12 20W	Mag-STD	1	20	25	8.5
F22SS	F20T12	Fluorescent, (2) 24", STD lamps	2' 2-Lamp T12 20W	Mag-STD	2	20	50	8.5
F23SS	F20T12	Fluorescent, (3) 24", STD lamps	2' 3-Lamp T12 20W	Mag-STD	3	20	71	8.5
F24SS	F20T12	Fluorescent, (4) 24", STD lamps	2' 4-Lamp T12 20W	Mag-STD	4	20	100	8.5
F26SS/2	F20T12	Fluorescent, (6) 24", STD lamps, (2) ballasts	2' 6-Lamp T12 20W	Mag-STD	6	20	146	8.5
F21HS	F24T12/HO	Fluorescent, (1) 24", HO lamp	2' 1-Lamp T12HO	Mag-STD	1	35	62	8.5
F22HS	F24T12/HO	Fluorescent, (2) 24", HO lamps	2' 2-Lamp T12HO	Mag-STD	2	35	90	8.5
F32EL/T4	F25T12	Fluorescent, (2) 36" ES lamps, Tandem 4-lamp ballast, NLO (0.85 < BF < 0.95)	3' 2-Lamp T12ES	Electronic	2	25	50	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F41IAL	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start Ballast	4' 1-Lamp T12 25W	Electronic	1	25	25	15.5
F41IAL/T2 -R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Tandem 2-Lamp IS ballast, RLO (BF < 0.85)	4' 1-Lamp T12 25W RLO	Electronic	1	25	19	15.5
F41IAL/T3 -R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Tandem 3-Lamp IS ballast, RLO (BF < 0.85)	4' 1-Lamp T12 25W RLO	Electronic	1	25	20	15.5
F41IAL/T4 -R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Tandem 4-Lamp IS ballast, RLO (BF < 0.85)	4' 1-Lamp T12 25W RLO	Electronic	1	25	20	15.5
F42IAL-R	F25T12	Fluorescent, (2) 48", F25T12 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 2-Lamp T12 25W RLO	Electronic	2	25	39	15.5
F42IAL/T4 -R	F25T12	Fluorescent, (2) 48", F25T12 lamps, Tandem 4-lamp IS Ballast, RLO (BF < 0.85)	4' 2-Lamp T12 25W RLO	Electronic	2	25	40	15.5
F43IAL-R	F25T12	Fluorescent, (3) 48", F25T12 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 3-Lamp T12 25W RLO	Electronic	3	25	60	15.5
F44IAL-R	F25T12	Fluorescent, (4) 48", F25T12 lamps, Instant Start Ballast, RLO (BF < 0.85)	4' 4-Lamp T12 25W RLO	Electronic	4	25	80	15.5
F31SE/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem 2-lamp ballast	3' 1-Lamp T12	Mag-ES	1	30	37	8.5
F31SL	F30T12	Fluorescent, (1) 36", STD lamp	3' 1-Lamp T12	Electronic	1	30	31	15.5
F31SS	F30T12	Fluorescent, (1) 36", STD lamp	3' 1-Lamp T12	Mag-STD	1	30	46	8.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F31SS/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem 2-lamp ballast	3' 1-Lamp T12	Mag-STD	1	30	41	8.5
F32SE	F30T12	Fluorescent, (2) 36", STD lamps	3' 2-Lamp T12	Mag-ES	2	30	74	8.5
F32SL	F30T12	Fluorescent, (2) 36", STD lamps	3' 2-Lamp T12	Electronic	2	30	58	15.5
F32SS	F30T12	Fluorescent, (2) 36", STD lamps	3' 2-Lamp T12	Mag-STD	2	30	75	8.5
F33SE	F30T12	Fluorescent, (3) 36", STD lamps, (1) STD ballast and (1) ES ballast	3' 3-Lamp T12	Mag-ES	3	30	120	8.5
F33SS	F30T12	Fluorescent, (3) 36", STD lamps	3' 3-Lamp T12	Mag-STD	3	30	127	8.5
F34SE	F30T12	Fluorescent, (4) 36", STD lamps	3' 4-Lamp T12	Mag-ES	4	30	148	8.5
F34SL	F30T12	Fluorescent, (4) 36", STD lamps	3' 4-Lamp T12	Electronic	4	30	116	15.5
F34SS	F30T12	Fluorescent, (4) 36", STD lamps	3' 4-Lamp T12	Mag-STD	4	30	150	8.5
F36SE	F30T12	Fluorescent, (6) 36", STD lamps	3' 6-Lamp T12ES	Mag-ES	6	30	213	8.5
F36SS	F30T12	Fluorescent, (6) 36", STD lamps	3' 6-Lamp T12	Mag-STD	6	30	225	8.5
F31EE/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem 2-lamp ballast	3' 1-Lamp T12ES	Mag-ES	1	25	33	8.5
F31EL	F30T12/ES	Fluorescent, (1) 36", ES lamp	3' 1-Lamp T12ES	Electronic	1	25	26	15.5
F31ES	F30T12/ES	Fluorescent, (1) 36", ES lamp	3' 1-Lamp T12ES	Mag-STD	1	25	42	8.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F31ES/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem 2-lamp ballast	3' 1-Lamp T12ES	Mag-STD	1	25	33	8.5
F32EE	F30T12/ES	Fluorescent, (2) 36", ES lamps	3' 1-Lamp T12ES	Mag-ES	2	25	66	8.5
F32EL	F30T12/ES	Fluorescent, (2) 36", ES lamps	3' 1-Lamp T12ES	Electronic	2	25	50	15.5
F32ES	F30T12/ES	Fluorescent, (2) 36", ES lamps	3' 1-Lamp T12ES	Mag-STD	2	25	73	8.5
F33ES	F30T12/ES	Fluorescent, (3) 36", ES lamps	3' 2-Lamp T12ES	Mag-STD	3	25	115	8.5
F34EE	F30T12/ES	Fluorescent, (4) 36", ES lamps	3' 4-Lamp T12ES	Mag-ES	4	25	132	8.5
F36EE	F30T12/ES	Fluorescent, (6) 36", ES lamps	3' 6-Lamp T12ES	Mag-ES	6	30	198	8.5
F36ES	F30T12/ES	Fluorescent, (6) 36", ES lamps	3' 6-Lamp T12ES	Mag-STD	6	30	219	8.5
F31SHS	F36T12/HO	Fluorescent, (1) 36", HO lamp	3' 1-Lamp T5HO	Mag-STD	1	50	70	8.5
F32SHS	F36T12/HO	Fluorescent, (2) 36", HO, lamps	3' 2-Lamp T12HO	Mag-STD	2	50	114	8.5
F41SIL	F40T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast	4' 1-Lamp T12	Electronic	1	39	46	15.5
F41SIL/T2	F40T12	Fluorescent, (1) 48", STD IS lamp, Tandem 2-lamp IS ballast	4' 1-Lamp T12	Electronic	1	39	37	15.5
F42SIL	F40T12	Fluorescent, (2) 48", STD IS lamps, Electronic ballast	4' 2-Lamp T12IS	Electronic	2	39	74	15.5
F43SIL	F40T12	Fluorescent, (3) 48", STD IS lamps, Electronic ballast	4' 3-Lamp T12IS	Electronic	3	39	120	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F44SIL	F40T12	Fluorescent, (4) 48", STD IS lamps, Electronic ballast	4' 4-Lamp T12IS	Electronic	4	39	148	15.5
F46SL	F40T12	Fluorescent, (6) 48", STD lamps	4' 4-Lamp T12	Electronic	6	40	186	15.5
F41TS	F40T10	Fluorescent, (1) 48", T-10 lamp	4' 1-Lamp T10	Mag-STD	1	40	51	8.5
F41EE	F40T12/ES	Fluorescent, (1) 48", ES lamp	4' 1-Lamp T12ES	Mag-ES	1	34	43	8.5
F41EE/2	F40T12/ES	Fluorescent, (1) 48", ES lamp, 2 ballast	4' 1-Lamp T12ES	Mag-ES	1	34	43	8.5
F41EE/T2	F40T12/ES	Fluorescent, (1) 48", ES lamp, Tandem 2-lamp ballast	4' 1-Lamp T12ES	Mag-ES	1	34	36	8.5
F41EL	F40T12/ES	Fluorescent, (1) 48", T12 ES lamp, Electronic Ballast	4' 1-Lamp T12ES	Electronic	1	34	32	15.5
F42EE	F40T12/ES	Fluorescent, (2) 48", ES lamp	4' 2-Lamp T12ES	Mag-ES	2	34	72	8.5
F42EE/2	F40T12/ES	Fluorescent, (2) 48", ES lamps, (2) 1-lamp ballasts	4' 2-Lamp T12ES	Mag-ES	2	34	86	8.5
F42EE/D2	F40T12/ES	Fluorescent, (2) 48", ES lamps, 2 Ballasts (delamped)	4' 2-Lamp T12ES	Mag-ES	2	34	76	8.5
F42EL	F40T12/ES	Fluorescent, (2) 48", T12 ES lamps, Electronic Ballast	4' 2-Lamp T12ES	Electronic	2	34	60	15.5
F43EE	F40T12/ES	Fluorescent, (3) 48", ES lamps	4' 3-Lamp T12ES	Mag-ES	3	34	115	8.5
F43EE/T2	F40T12/ES	Fluorescent, (3) 48", ES lamps, Tandem 2-lamp ballasts	4' 3-Lamp T12ES	Mag-ES	3	34	108	8.5
F43EL	F40T12/ES	Fluorescent, (3) 48", T12 ES lamps, Electronic Ballast	4' 3-Lamp T12ES	Electronic	3	34	92	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F44EE	F40T12/ES	Fluorescent, (4) 48", ES lamps	4' 3-Lamp T12ES	Mag-ES	4	34	144	8.5
F44EE/D3	F40T12/ES	Fluorescent, (4) 48", ES lamps, 3 Ballasts (delamped)	4' 4-Lamp T12ES	Mag-ES	4	34	148	8.5
F44EE/D4	F40T12/ES	Fluorescent, (4) 48", ES lamps, 4 Ballasts (delamped)	4' 3-Lamp T12ES	Mag-ES	4	34	152	8.5
F44EL	F40T12/ES	Fluorescent, (4) 48", T12 ES lamps, Electronic Ballast	4' 4-Lamp T12ES	Electronic	4	34	120	15.5
F46EE	F40T12/ES	Fluorescent, (6) 48", ES lamps	4' 6-Lamp T12ES	Mag-ES	6	34	216	8.5
F46EL	F40T12/ES	Fluorescent, (6) 48", ES lamps	4' 6-Lamp T12ES	Electronic	6	34	180	15.5
F48EE	F40T12/ES	Fluorescent, (8) 48", ES lamps	4' 8-Lamp T12ES	Mag-ES	8	34	288	8.5
F42EHS	F42T12/HO/ ES	Fluorescent, (2) 42", HO lamps (3.5' lamp)	4' 2-Lamp T12HO	Mag-STD	2	55	135	8.5
F43EHS	F42T12/HO/ ES	Fluorescent, (3) 42", HO lamps (3.5' lamp)	4' 3-Lamp T12ES HO	Mag-STD	3	55	215	8.5
F41EIS	F48T12/ES	Fluorescent, (1) 48" ES Instant Start lamp. Magnetic ballast	4' 1-Lamp T12ES	Mag-STD	1	40	51	8.5
F42EIS	F48T12/ES	Fluorescent, (2) 48" ES Instant Start lamps. Magnetic ballast	4' 2-Lamp T12ES	Mag-STD	2	40	82	8.5
F43EIS	F48T12/ES	Fluorescent, (3) 48" ES Instant Start lamps. Magnetic ballast	4' 3-Lamp T12ES	Mag-STD	3	40	133	8.5
F44EIS	F48T12/ES	Fluorescent, (4) 48" ES Instant Start lamps. Magnetic ballast	4' 4-Lamp T12IS	Mag-STD	4	40	164	8.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F41SHS	F48T12/HO	Fluorescent, (1) 48", STD HO lamp	4' 1-Lamp T12HO	Mag-STD	1	60	85	8.5
F42SHS	F48T12/HO	Fluorescent, (2) 48", STD HO lamps	4' 2-Lamp T12HO	Mag-STD	2	60	145	8.5
F43SHS	F48T12/HO	Fluorescent, (3) 48", STD HO lamps	4' 3-Lamp T12HO	Mag-STD	3	60	230	8.5
F44SHS	F48T12/HO	Fluorescent, (4) 48", STD HO lamps	4' 4-Lamp T12HO	Mag-STD	4	60	290	8.5
F41EHS	F48T12/HO/ ES	Fluorescent, (1) 48", ES HO lamp	4' 1-Lamp T12HO	Mag-STD	1	55	80	8.5
F44EHS	F48T12/HO/ ES	Fluorescent, (4) 48", ES HO lamps	4' 3-Lamp T12ES HO	Mag-STD	4	55	270	8.5
F41SVS	F48T12/VHO	Fluorescent, (1) 48", STD VHO lamp	4' 1-Lamp T12VHO	Mag-STD	1	110	140	8.5
F42SVS	F48T12/VHO	Fluorescent, (2) 48", STD VHO lamps	4' 2-Lamp T12VHO	Mag-STD	2	110	252	8.5
F43SVS	F48T12/VHO	Fluorescent, (3) 48", STD VHO lamps	4' 3-Lamp T12VHO	Mag-STD	3	110	377	8.5
F44SVS	F48T12/VHO	Fluorescent, (4) 48", STD VHO lamps	4' 4-Lamp T12VHO	Mag-STD	4	110	484	8.5
F44EVS	F48T12/VHO /ES	Fluorescent, (4) 48", VHO ES lamps	4' 4-Lamp T12VHO	Mag-STD	4	100	420	8.5
F51SL	F60T12	Fluorescent, (1) 60", STD lamp	5' 1-Lamp T12	Electronic	1	50	44	15.5
F51SS	F60T12	Fluorescent, (1) 60", STD lamp	5' 1-Lamp T12	Mag-STD	1	50	63	8.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F52SL	F60T12	Fluorescent, (2) 60", STD lamps	5' 2-Lamp T12	Electronic	2	50	88	15.5
F52SS	F60T12	Fluorescent, (2) 60", STD lamps	5' 2-Lamp T12	Mag-STD	2	50	128	8.5
F51SHE	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	5' 1-Lamp T12HO	Mag-ES	1	75	88	8.5
F51SHL	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	5' 1-Lamp T12HO	Electronic	1	75	69	15.5
F51SHS	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	5' 1-Lamp T12HO	Mag-STD	1	75	92	8.5
F52SHE	F60T12/HO	Fluorescent, (2) 60", STD HO lamps	5' 2-Lamp T12HO	Mag-ES	2	75	176	8.5
F52SHL	F60T12/HO	Fluorescent, (2) 60", STD HO lamps	5' 2-Lamp T12HO	Electronic	2	75	138	15.5
F52SHS	F60T12/HO	Fluorescent, (2) 60", STD HO lamps	5' 2-Lamp T12HO	Mag-STD	2	75	168	8.5
F51SVS	F60T12/VHO	Fluorescent, (1) 60", VHO ES lamp	5' 1-Lamp T12VHO	Mag-STD	1	135	165	8.5
F52SVS	F60T12/VHO	Fluorescent, (2) 60", VHO ES lamps	5' 2-Lamp T12VHO	Mag-STD	2	135	310	8.5
F61ISL	F72T12	Fluorescent, (1) 72", STD lamp, IS electronic ballast	6' 1-Lamp T12	Electronic	1	55	68	15.5
F61SS	F72T12	Fluorescent, (1) 72", STD lamp	6' 1-Lamp T12	Mag-STD	1	55	76	8.5
F62ISL	F72T12	Fluorescent, (2) 72", STD lamps, IS electronic ballast	6' 2-Lamp T12IS	Electronic	2	55	108	15.5
F62SE	F72T12	Fluorescent, (2) 72", STD lamps	6' 2-Lamp T12	Mag-ES	2	55	122	8.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F62SL	F72T12	Fluorescent, (2) 72", STD lamps	6' 2-Lamp T12	Electronic	2	55	108	15.5
F62SS	F72T12	Fluorescent, (2) 72", STD lamps	6' 2-Lamp T12	Mag-STD	2	55	142	8.5
F63ISL	F72T12	Fluorescent, (3) 72", STD lamps, IS electronic ballast	6' 3-Lamp T12IS	Electronic	3	55	176	15.5
F63SS	F72T12	Fluorescent, (3) 72", STD lamps	6' 3-Lamp T12	Mag-STD	3	55	202	8.5
F64ISL	F72T12	Fluorescent, (4) 72", STD lamps, IS electronic ballast	6' 4-Lamp T12IS	Electronic	4	55	216	15.5
F64SE	F72T12	Fluorescent, (4) 72", STD lamps	6' 4-Lamp T12	Mag-ES	4	55	244	8.5
F64SS	F72T12	Fluorescent, (4) 72", STD lamps	6' 4-Lamp T12	Mag-STD	4	56	244	8.5
F61SHS	F72T12/HO	Fluorescent, (1) 72", STD HO lamp	6' 1-Lamp T12HO	Mag-STD	1	85	106	8.5
F62SHE	F72T12/HO	Fluorescent, (2) 72", STD HO lamps	6' 2-Lamp T12HO	Mag-ES	2	85	194	8.5
F62SHL	F72T12/HO	Fluorescent, (2) 72", STD HO lamps	6' 2-Lamp T12HO	Electronic	2	85	167	15.5
F62SHS	F72T12/HO	Fluorescent, (2) 72", STD HO lamps	6' 2-Lamp T12HO	Mag-STD	2	85	200	8.5
F64SHE	F72T12/HO	Fluorescent, (4) 72", HO lamps	6' 4-Lamp T12HO	Mag-ES	4	85	388	8.5
F61SVS	F72T12/VHO	Fluorescent, (1) 72", VHO lamp	6' 1-Lamp T12VHO	Mag-STD	1	160	180	8.5
F62SVS	F72T12/VHO	Fluorescent, (2) 72", VHO lamps	6' 2-Lamp T12VHO	Mag-STD	2	160	330	8.5

Fixture Code	***LAMP CODE***	***DESCRIPTION***	***Layman Term***	***BALLAST***	***LAMP / FIXT***	***W / LAMP***	***W / FIXT***	***EUL***
F71HS	F84T12/HO	Fluorescent, (1) 84", HO lamp	7' 1-Lamp T12HO	Mag-ES	1	100	104	8.5
F72HS	F84T12/HO	Fluorescent, (2) 84", HO lamp	7' 2-Lamp T12HO	Mag-ES	2	100	198	8.5
F81SL	F96T12	Fluorescent, (1) 96", STD lamp	8' 1-Lamp T12	Electronic	1	75	69	15.5
F81SL/T2	F96T12	Fluorescent, (1) 96", STD lamp, Tandem 2-lamp ballast	8' 1-Lamp T12	Electronic	1	75	55	15.5
F82SL	F96T12	Fluorescent, (2) 96", STD lamps	8' 2-Lamp T12	Electronic	2	75	110	15.5
F83SL	F96T12	Fluorescent, (3) 96", STD lamps	8' 3-Lamp T12	Electronic	3	75	179	15.5
F84SL	F96T12	Fluorescent, (4) 96", STD lamps	8' 4-Lamp T12	Electronic	4	75	220	15.5
F81EE	F96T12/ES	Fluorescent, (1) 96" ES lamp	8' 4-Lamp T12ES	Mag-ES	1	60	75	8.5
F81EE/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, Tandem 2-lamp ballast	8' 1-Lamp T12ES	Mag-ES	1	60	62	8.5
F81EL	F96T12/ES	Fluorescent, (1) 96", ES lamp	8' 1-Lamp T12ES	Electronic	1	60	69	15.5
F81EL/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, Tandem 2-lamp ballast	8' 1-Lamp T12ES	Electronic	1	60	55	15.5
F82EE	F96T12/ES	Fluorescent, (2) 96", ES lamps	8' 2-Lamp T12ES	Mag-ES	2	60	123	8.5
F82EL	F96T12/ES	Fluorescent, (2) 96", ES lamps	8' 2-Lamp T12ES	Electronic	2	60	110	15.5
F83EE	F96T12/ES	Fluorescent, (3) 96", ES lamps	8' 3-Lamp T12ES	Mag-ES	3	60	198	8.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F83EL	F96T12/ES	Fluorescent, (3) 96", ES lamps	8' 3-Lamp T12ES	Electronic	3	60	179	15.5
F84EE	F96T12/ES	Fluorescent, (4) 96", ES lamps	8' 4-Lamp T12ES	Mag-ES	4	60	246	8.5
F84EL	F96T12/ES	Fluorescent, (4) 96", ES lamps	8' 4-Lamp T12ES	Electronic	4	60	220	15.5
F86EE	F96T12/ES	Fluorescent, (6) 96", ES lamps	8' 6-Lamp T12ES	Mag-ES	6	60	369	8.5
F81SHS	F96T12/HO	Fluorescent, (1) 96", STD HO lamp	8' 1-Lamp T12HO	Mag-STD	1	110	121	8.5
F82SHE	F96T12/HO	Fluorescent, (2) 96", STD HO lamps	8' 2-Lamp T12HO	Mag-ES	2	110	207	8.5
F82SHL	F96T12/HO	Fluorescent, (2) 96", STD HO lamps	8' 2-Lamp T12HO	Electronic	2	110	173	15.5
F82SHS	F96T12/HO	Fluorescent, (2) 96", STD HO lamps	8' 2-Lamp T12HO	Mag-STD	2	110	207	8.5
F83SHE	F96T12/HO	Fluorescent, (3) 96", STD HO lamps	8' 3-Lamp T12HO	Mag-ES	3	110	319	8.5
F83SHS	F96T12/HO	Fluorescent, (3) 96", STD HO lamps	8' 3-Lamp T12HO	Mag-STD	3	110	319	8.5
F84SHE	F96T12/HO	Fluorescent, (4) 96", STD HO lamps	8' 4-Lamp T12HO	Mag-ES	4	110	414	8.5
F84SHL	F96T12/HO	Fluorescent, (4) 96", STD HO lamps	8' 4-Lamp T12HO	Electronic	4	110	346	15.5
F84SHS	F96T12/HO	Fluorescent, (4) 96", STD HO lamps	8' 4-Lamp T12HO	Mag-STD	4	110	414	8.5
F88SHS	F96T12/HO	Fluorescent, (8) 96", STD HO lamps	8' 8-Lamp T12HO	Mag-STD	8	110	828	8.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F81EHL	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	8' 1-Lamp T12ES HO	Electronic	1	95	80	15.5
F81EHS	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	8' 1-Lamp T12ES HO	Mag-STD	1	95	113	8.5
F82EHE	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamps	8' 2-Lamp T12ES HO	Mag-ES	2	95	207	8.5
F82EHL	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamps	8' 2-Lamp T12ES HO	Electronic	2	95	173	15.5
F82EHS	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamps	8' 2-Lamp T12ES HO	Mag-STD	2	95	207	8.5
F83EHE	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamps, (1) 2-lamp ES Ballast and (1) 1-lamp STD Ballast	8' 3-Lamp T12ES HO	Mag-ES/STD	3	95	319	8.5
F83EHS	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamps	8' 3-Lamp T12ES HO	Mag-STD	3	95	319	8.5
F84EHE	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamps	8' 4-Lamp T12ES HO	Mag-ES	4	95	414	8.5
F84EHL	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamps	8' 4-Lamp T12ES HO	Electronic	4	95	346	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
F84EHS	F96T12/HO/ ES	Fluorescent, (4) 96", ES HO lamps	8' 4-Lamp T12ES HO	Mag-STD	4	95	414	8.5
F86EHS	F96T12/HO/ ES	Fluorescent, (6) 96", ES HO lamps	8' 6-Lamp T12ES HO	Mag-STD	6	95	519	8.5
F88EHE	F96T12/HO/ ES	Fluorescent, (8) 96", ES HO lamps	8' 8-Lamp T12ES HO	Mag-ES	8	95	828	8.5
F81SVS	F96T12/VHO	Fluorescent, (1) 96", STD VHO lamp	8' 1-Lamp T12VHO	Mag-STD	1	215	205	8.5
F82SVS	F96T12/VHO	Fluorescent, (2) 96", STD VHO lamps	8' 2-Lamp T12VHO	Mag-STD	2	215	380	8.5
F83SVS	F96T12/VHO	Fluorescent, (3) 96", STD VHO lamps	8' 3-Lamp T12VHO	Mag-STD	3	215	585	8.5
F84SVS	F96T12/VHO	Fluorescent, (4) 96", STD VHO lamps	8' 4-Lamp T12VHO	Mag-STD	4	215	760	8.5
F81EVS	F96T12/VHO /ES	Fluorescent, (1) 96", ES VHO lamp	8' 1-Lamp T12ES VHO	Mag-STD	1	185	205	8.5
F82EVS	F96T12/VHO /ES	Fluorescent, (2) 96", ES VHO lamps	8' 2-Lamp T12ES VHO	Mag-STD	2	195	380	8.5
F83EVS	F96T12/VHO /ES	Fluorescent, (3) 96", ES VHO lamps	8' 3-Lamp T12ES VHO	Mag-STD	3	185	585	8.5
F84EVS	F96T12/VHO /ES	Fluorescent, (4) 96", ES VHO lamps	8' 4-Lamp T12ES VHO	Mag-STD	4	185	760	8.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
F81SGS	F96T17	Fluorescent, (1) 96", T17 Grooved lamp	8' 1-Lamp T12	Mag-STD	1	215	235	8.5
F40SE/D1	None	Fluorescent, (0) 48" lamps, Completely delamped fixture with (1) hot ballast		Mag-ES	1	0	4	8.5
F40SE/D2	None	Fluorescent, (0) 48" lamps, Completely delamped fixture with (2) hot ballast		Mag-ES	1	0	8	8.5
FC		Circline Fluorescent Fixtures						
FC6/1	FC6T9	Fluorescent, (1) 6" circular lamp, RS ballast	6" 1-Lamp T9 Cir	Mag-STD	1	20	25	15.5
FC8/1	FC8T9	Fluorescent, (1) 8" circular lamp, RS ballast	8" 1-Lamp T9 Cir	Mag-STD	1	22	26	15.5
FC8/2	FC8T9	Fluorescent, (2) 8" circular lamps, RS ballast	8" 2-Lamp T9 Cir	Mag-STD	2	22	52	15.5
FC20	FC6T9	Fluorescent, Circline, (1) 20W lamp, preheat ballast	20W 1-Lamp T9 Cir	Mag-STD	1	20	20	15.5
FC22	FC8T9	Fluorescent, Circline, (1) 22W lamp, preheat ballast	22W 1-Lamp T9 Cir	Mag-STD	1	22	20	15.5
FC12/1	FC12T9	Fluorescent, (1) 12" circular lamp, RS ballast	12" 1-Lamp T9 Cir	Mag-STD	1	32	31	15.5
FC12/2	FC12T9	Fluorescent, (2) 12" circular lamps, RS ballast	12" 2-Lamp T9 Cir	Mag-STD	2	32	62	15.5
FC32	FC12T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	32W 1-Lamp T9 Cir	Mag-STD	1	32	40	15.5
FC16/1	FC16T9	Fluorescent, (1) 16" circular lamp	16" 1-Lamp T9 Cir	Mag-STD	1	40	35	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
FC40	FC16T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	40W 1-Lamp T9 Cir	Mag-STD	1	32	42	15.5
FEI		Fluorescent Electrodeless Induction Fixtures						
FEI40/1	CFT40W	Electrodeless Fluorescent System, (1) 40W lamp	1-Lamp 40W Induction	Electronic	1	40	44	15.5
FEI55/1	CFT55W	Electrodeless Fluorescent System, (1) 55W lamp	1-Lamp 55W Induction	Electronic	1	55	59	15.5
FEI60/1	CFT60W	Electrodeless Fluorescent System, (1) 60W lamp	1-Lamp 60W Induction	Electronic	1	60	64	15.5
FEI70/1	CFT70W	Electrodeless Fluorescent System, (1) 70W lamp	1-Lamp 70W Induction	Electronic	1	70	74	15.5
FEI80/1	CFT80W	Electrodeless Fluorescent System, (1) 80W lamp	1-Lamp 80W Induction	Electronic	1	80	84	15.5
FEI85/1	CFT85W	Electrodeless Fluorescent System, (1) 85W lamp	1-Lamp 85W Induction	Electronic	1	85	89	15.5
FEI100/1	CFT100W	Electrodeless Fluorescent System, (1) 100W lamp	1-Lamp 100W Induction	Electronic	1	100	105	15.5
FEI125/1	CFT125W	Electrodeless Fluorescent System, (1) 125W lamp	1-Lamp 125W Induction	Electronic	1	125	131	15.5
FEI150/1	CFT150W	Electrodeless Fluorescent System, (1) 150W lamp	1-Lamp 150W Induction	Electronic	1	150	157	15.5
FEI165/1	CFT165W	Electrodeless Fluorescent System, (1) 165W lamp	1-Lamp 165W Induction	Electronic	1	165	173	15.5
FEI200/1	CFT200W	Electrodeless Fluorescent System, (1) 200W lamp	1-Lamp 200W Induction	Electronic	1	200	210	15.5
FEI250/1	CFT250W	Electrodeless Fluorescent System, (1) 250W lamp	1-Lamp 250W Induction	Electronic	1	250	263	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
FEI300/1	CFT300W	Electrodeless Fluorescent System, (1) 300W lamp	1-Lamp 300W Induction	Electronic	1	300	315	15.5
FEI400/1	CFT400W	Electrodeless Fluorescent System, (1) 400W lamp	1-Lamp 400W Induction	Electronic	1	400	420	15.5
FU		U-Tube Fluorescent Fixtures						
FU1ILL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, Instant Start ballast	1-Lamp T8 U-Tube	Electronic	1	32	31	15.5
FU1LL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp	1-Lamp T8 U-Tube	Electronic	1	32	32	15.5
FU1LL-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, RLO (BF < 0.85)	1-Lamp T8 U-Tube	Electronic	1	31	27	15.5
FU2ILL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, Instant Start Ballast	1-Lamp T8 U-Tube	Electronic	2	32	59	15.5
FU2ILL-H	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, Instant Start HLO Ballast	2-Lamp T8 HLO U-Tube	Electronic	2	32	65	15.5
FU2ILL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, Instant Start RLO Ballast	2-Lamp T8 RLO U-Tube	Electronic	2	32	52	15.5
FU2ILL/T4	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, Instant Start Ballast, Tandem 4-lamp ballast	2-Lamp T8 U-Tube	Electronic	2	32	56	15.5
FU2ILL/T4-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, Instant Start Ballast, RLO, Tandem 4-lamp ballast	2-Lamp T8 RLO U-Tube	Electronic	2	32	49	15.5
FU2LL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps	2-Lamp T8 U-Tube	Electronic	2	32	60	15.5
FU2LL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, RLO (BF < 0.85)	2-Lamp T8 RLO U-Tube	Electronic	2	31	54	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
FU2LL/T2	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamps, Tandem 4-lamp ballast	2-Lamp T8 U-Tube	Electronic	2	32	59	15.5
FU3ILL	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamps, Instant Start Ballast	3-Lamp T8 U-Tube	Electronic	3	32	89	15.5
FU3ILL-R	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamps, Instant Start RLO Ballast	3-Lamp T8ES U-Tube	Electronic	3	32	78	15.5
FU1ILU	FU32T8/6	Fluorescent, (1) 6" spacing U-Tube, T-8 lamp, IS Ballast, NLO (0.85 < BF < 0.95)	1-Lamp T8 6" Spacing U-Tube	Electronic	1	32	29	15.5
FU1ILU-H	FU32T8/6	Fluorescent, (1) 6" spacing U-Tube, T-8 lamp, IS Ballast, HLO (.95 < BF < 1.1)	1-Lamp T8 6" Spacing U-Tube HLO	Electronic	1	32	34	15.5
FU2ILU	FU32T8/6	Fluorescent, (2) 6" spacing U-Tube, T-8 lamps, IS Ballast, NLO (0.85 < BF < 0.95)	2-Lamp T8 6" Spacing U-Tube	Electronic	2	32	55	15.5
FU2ILU-R	FU32T8/6	Fluorescent, (2) 6" spacing U-Tube, T-8 lamps, IS Ballast, RLO (BF < 0.85)	2-Lamp T8 6" Spacing U-Tube RLO	Electronic	2	32	48	15.5
FU2ILU-V	FU32T8/6	Fluorescent, (2) 6" spacing U-Tube, T-8 lamps, IS Ballast, VHLO (BF > 1.1)	2-Lamp T8 6" Spacing U-Tube VHLO	Electronic	2	32	73	15.5
FU3ILU	FU32T8/6	Fluorescent, (3) 6" spacing U-Tube, T-8 lamps, IS Ballast, NLO (0.85 < BF < 0.95)	3-Lamp T8 6" Spacing U-Tube	Electronic	3	32	81	15.5
FU3ILU-R	FU32T8/6	Fluorescent, (3) 6" spacing U-Tube, T-8 lamps, IS Ballast, RLO (BF < 0.85)	3-Lamp T8 6" Spacing U-Tube RLO	Electronic	3	32	73	15.5
FU1SE	FU40T12	Fluorescent, (1) U-Tube, STD lamp	1-Lamp T12 U-Tube	Mag-ES	1	40	43	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
FU1SS	FU40T12	Fluorescent, (1) U-Tube, ES Lamp	1-Lamp T12 U-Tube ES	Mag-STD	1	40	43	8.5
FU2SE	FU40T12	Fluorescent, (2) U-Tube, STD lamps	2-Lamp T12 U-Tube	Mag-ES	2	40	72	15.5
FU2SL	FU40T12	Fluorescent (2) 48" U-bent Standard lamps, Electronic ballast, NLO (0.85 < BF < 0.95)	2-Lamp T12 U-Tube	Electronic	2	40	63	15.5
FU2SS	FU40T12	Fluorescent, (1) U-Tube, STD lamp, STD Mag Ballast	2-Lamp T12 U-Tube	Mag-STD	2	40	72	8.5
FU3SE	FU40T12	Fluorescent, (3) U-Tube, STD lamps	3-Lamp T12 U-Tube	Mag-ES	3	40	115	15.5
FU1EE	FU40T12/ES	Fluorescent, (1) U-Tube, ES lamp	1-Lamp T12ES U-Tube	Mag-ES	1	35	43	15.5
FU1ES	FU40T12/ES	Fluorescent, (1) U-Tube, ES Lamp	1-Lamp T12ES U-Tube	Mag-STD	1	34	43	8.5
FU2EE	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamps	1-Lamp T12ES U-Tube	Mag-ES	2	35	72	15.5
FU2EL	FU40T12/ES	Fluorescent (2) 48" U-bent ES lamps, Electronic ballast, NLO (0.85 < BF < 0.95)	1-Lamp T12ES U-Tube	Electronic	2	34	63	15.5
FU2ES	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamps	1-Lamp T12ES U-Tube	Mag-STD	1	35	72	8.5
FU3EE	FU40T12/ES	Fluorescent, (3) U-Tube, ES lamps	3-Lamp T12ES U-Tube	Mag-ES	3	35	115	15.5
H		Halogen Incandescent Fixtures						
H20/1	H20	Halogen, (1) 20W lamp	20W 1-Lamp Halogen		1	20	20	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
H21/1	H21	Halogen, (1) 21W lamp	21W 1-Lamp Halogen		1	21	21	1.5
H22/1	H22	Halogen, (1) 22W lamp	22W 1-Lamp Halogen		1	22	22	1.5
H23/1	H23	Halogen, (1) 23W lamp	23W 1-Lamp Halogen		1	23	23	1.5
H24/1	H24	Halogen, (1) 24W lamp	24W 1-Lamp Halogen		1	24	24	1.5
H25/1	H25	Halogen, (1) 25W lamp	25W 1-Lamp Halogen		1	25	25	1.5
H26/1	H26	Halogen, (1) 26W lamp	26W 1-Lamp Halogen		1	26	26	1.5
H27/1	H27	Halogen, (1) 27W lamp	27W 1-Lamp Halogen		1	27	27	1.5
H28/1	H28	Halogen, (1) 28W lamp	28W 1-Lamp Halogen		1	28	28	1.5
H29/1	H29	Halogen, (1) 29W lamp	29W 1-Lamp Halogen		1	29	29	1.5
H30/1	H30	Halogen, (1) 30W lamp	30W 1-Lamp Halogen		1	30	30	1.5
H31/1	H31	Halogen, (1) 31W lamp	31W 1-Lamp Halogen		1	31	31	1.5
H32/1	H32	Halogen, (1) 32W lamp	32W 1-Lamp Halogen		1	32	32	1.5
H33/1	H33	Halogen, (1) 33W lamp	33W 1-Lamp Halogen		1	33	33	1.5
H34/1	H34	Halogen, (1) 34W lamp	34W 1-Lamp Halogen		1	34	34	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
H35/1	H35	Halogen, (1) 35W lamp	35W 1-Lamp Halogen		1	35	35	1.5
H36/1	H36	Halogen, (1) 36W lamp	36W 1-Lamp Halogen		1	36	36	1.5
H37/1	H37	Halogen, (1) 37W lamp	37W 1-Lamp Halogen		1	37	37	1.5
H38/1	H38	Halogen, (1) 38W lamp	38W 1-Lamp Halogen		1	38	38	1.5
H39/1	H39	Halogen, (1) 39W lamp	39W 1-Lamp Halogen		1	39	39	1.5
H40/1	H40	Halogen, (1) 40W lamp	40W 1-Lamp Halogen		1	40	40	1.5
H41/1	H41	Halogen, (1) 41W lamp	41W 1-Lamp Halogen		1	41	41	1.5
H42/1	H42	Halogen, (1) 42W lamp	42W 1-Lamp Halogen		1	42	42	1.5
H43/1	H43	Halogen, (1) 43W lamp	43W 1-Lamp Halogen		1	43	43	1.5
H44/1	H44	Halogen, (1) 44W lamp	44W 1-Lamp Halogen		1	44	44	1.5
H45/1	H45	Halogen, (1) 45W lamp	45W 1-Lamp Halogen		1	45	45	1.5
H46/1	H46	Halogen, (1) 46W lamp	46W 1-Lamp Halogen		1	46	46	1.5
H47/1	H47	Halogen, (1) 47W lamp	47W 1-Lamp Halogen		1	47	47	1.5
H48/1	H48	Halogen, (1) 48W lamp	48W 1-Lamp Halogen		1	48	48	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
H49/1	H49	Halogen, (1) 49W lamp	49W 1-Lamp Halogen		1	49	49	1.5
H50/1	H50	Halogen, (1) 50W lamp	50W 1-Lamp Halogen		1	50	50	1.5
H51/1	H51	Halogen, (1) 51W lamp	51W 1-Lamp Halogen		1	51	51	1.5
H52/1	H52	Halogen, (1) 52W lamp	52W 1-Lamp Halogen		1	52	52	1.5
H53/1	H53	Halogen, (1) 53W lamp	53W 1-Lamp Halogen		1	53	53	1.5
H54/1	H54	Halogen, (1) 54W lamp	54W 1-Lamp Halogen		1	54	54	1.5
H55/1	H55	Halogen, (1) 55W lamp	55W 1-Lamp Halogen		1	55	55	1.5
H56/1	H56	Halogen, (1) 56W lamp	56W 1-Lamp Halogen		1	56	56	1.5
H57/1	H57	Halogen, (1) 57W lamp	57W 1-Lamp Halogen		1	57	57	1.5
H58/1	H58	Halogen, (1) 58W lamp	58W 1-Lamp Halogen		1	58	58	1.5
H59/1	H59	Halogen, (1) 59W lamp	59W 1-Lamp Halogen		1	59	59	1.5
H60/1	H60	Halogen, (1) 60W lamp	60W 1-Lamp Halogen		1	60	60	1.5
H61/1	H61	Halogen, (1) 61W lamp	61W 1-Lamp Halogen		1	61	61	1.5
H62/1	H62	Halogen, (1) 62W lamp	62W 1-Lamp Halogen		1	62	62	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
H63/1	H63	Halogen, (1) 63W lamp	63W 1-Lamp Halogen		1	63	63	1.5
H64/1	H64	Halogen, (1) 64W lamp	64W 1-Lamp Halogen		1	64	64	1.5
H65/1	H65	Halogen, (1) 65W lamp	65W 1-Lamp Halogen		1	65	65	1.5
H66/1	H66	Halogen, (1) 66W lamp	66W 1-Lamp Halogen		1	66	66	1.5
H67/1	H67	Halogen, (1) 67W lamp	67W 1-Lamp Halogen		1	67	67	1.5
H68/1	H68	Halogen, (1) 68W lamp	68W 1-Lamp Halogen		1	68	68	1.5
H69/1	H69	Halogen, (1) 69W lamp	69W 1-Lamp Halogen		1	69	69	1.5
H70/1	H70	Halogen, (1) 70W lamp	70W 1-Lamp Halogen		1	70	70	1.5
H71/1	H71	Halogen, (1) 71W lamp	71W 1-Lamp Halogen		1	71	71	1.5
H72/1	H72	Halogen, (1) 72W lamp	72W 1-Lamp Halogen		1	72	72	1.5
H73/1	H73	Halogen, (1) 73W lamp	73W 1-Lamp Halogen		1	73	73	1.5
H74/1	H74	Halogen, (1) 74W lamp	74W 1-Lamp Halogen		1	74	74	1.5
H75/1	H75	Halogen, (1) 75W lamp	75W 1-Lamp Halogen		1	75	75	1.5
H80/1	H80	Halogen, (1) 80W lamp	80W 1-Lamp Halogen		1	80	80	1.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
H90/1	H90	Halogen, (1) 90W lamp	90W 1-Lamp Halogen		1	90	90	1.5
H100/1	H100	Halogen, (1) 100W lamp	100W 1-Lamp Halogen		1	100	100	1.5
H150/1	H150	Halogen, (1) 150W lamp	150W 1-Lamp Halogen		1	150	150	1.5
H250/1	H250	Halogen, (1) 250W lamp	250W 1-Lamp Halogen		1	250	250	1.5
H300/1	H300	Halogen, (1) 300W lamp	300W 1-Lamp Halogen		1	300	300	1.5
H500/1	H500	Halogen, (1) 500W lamp	500W 1-Lamp Halogen		1	500	500	1.5
HPS		High Pressure Sodium Fixtures						
HPS35/1	HPS35	High Pressure Sodium, (1) 35W lamp	35W HPS		1	35	46	15.5
HPS50/1	HPS50	High Pressure Sodium, (1) 50W lamp	50W HPS		1	50	66	15.5
HPS70/1	HPS70	High Pressure Sodium, (1) 70W lamp	70W HPS		1	70	95	15.5
HPS100/1	HPS100	High Pressure Sodium, (1) 100W lamp	100W HPS		1	100	138	15.5
HPS150/1	HPS150	High Pressure Sodium, (1) 150W lamp	150W HPS		1	150	188	15.5
HPS200/1	HPS200	High Pressure Sodium, (1) 200W lamp	200W HPS		1	200	250	15.5
HPS250/1	HPS250	High Pressure Sodium, (1) 250W lamp	250W HPS		1	250	295	15.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
HPS310/1	HPS310	High Pressure Sodium, (1) 310W lamp	310W HPS		1	310	365	15.5
HPS360/1	HPS360	High Pressure Sodium, (1) 360W lamp	360W HPS		1	360	414	15.5
HPS400/1	HPS400	High Pressure Sodium, (1) 400W lamp	400W HPS		1	400	465	15.5
HPS1000/1	HPS1000	High Pressure Sodium, (1) 1000W lamp	1000W HPS		1	1000	1100	15.5
I		Standard Incandescent Fixtures						
I7.5/1	I7.5	Tungsten exit light, (1) 7.5 W lamp, used in night light application	7.5W incandescent		1	7.5	8	1.5
I10/1	I10	Incandescent, (1) 10W lamp	10W incandescent		1	10	10	1.5
I11/1	I11	Incandescent, (1) 11W lamp	11W incandescent		1	11	11	1.5
I12/1	I12	Incandescent, (1) 12W lamp	12W incandescent		1	12	12	1.5
I13/1	I13	Incandescent, (1) 13W lamp	13W incandescent		1	13	13	1.5
I14/1	I14	Incandescent, (1) 14W lamp	14W incandescent		1	14	14	1.5
I15/1	I15	Incandescent, (1) 15W lamp	15W incandescent		1	15	15	1.5
I16/1	I16	Incandescent, (1) 16W lamp	16W incandescent		1	16	16	1.5
I17/1	I17	Incandescent, (1) 17W lamp	17W incandescent		1	17	17	1.5

Fixture Code	*LAMP CODE*	*DESCRIPTION*	*Layman Term*	*BALLAST*	*LAMP / FIXT*	*W / LAMP*	*W / FIXT*	*EUL*
I18/1	I18	Incandescent, (1) 18W lamp	18W incandescent		1	18	18	1.5
I19/1	I19	Incandescent, (1) 19W lamp	19W incandescent		1	19	19	1.5
I20/1	I20	Incandescent, (1) 20W lamp	20W incandescent		1	20	20	1.5
I21/1	I21	Incandescent, (1) 21W lamp	21W incandescent		1	21	21	1.5
I22/1	I22	Incandescent, (1) 22W lamp	22W incandescent		1	22	22	1.5
I23/1	I23	Incandescent, (1) 23W lamp	23W incandescent		1	23	23	1.5
I24/1	I24	Incandescent, (1) 24W lamp	24W incandescent		1	24	24	1.5
I25/1	I25	Incandescent, (1) 25W lamp	25W incandescent		1	25	25	1.5
I26/1	I26	Incandescent, (1) 26W lamp	26W incandescent		1	26	26	1.5
I27/1	I27	Incandescent, (1) 27W lamp	27W incandescent		1	27	27	1.5
I28/1	I28	Incandescent, (1) 28W lamp	28W incandescent		1	28	28	1.5
I29/1	I29	Incandescent, (1) 29W lamp	29W incandescent		1	29	29	1.5
I30/1	I30	Incandescent, (1) 30W lamp	30W incandescent		1	30	30	1.5
I31/1	I31	Incandescent, (1) 31W lamp	31W incandescent		1	31	31	1.5

Fixture Code	***LAMP CODE***	***DESCRIPTION***	***Layman Term***	***BALLAST***	***LAMP / FIXT***	***W / LAMP***	***W / FIXT***	***EUL***
I32/1	I32	Incandescent, (1) 32W lamp	32W incandescent		1	32	32	1.5
I33/1	I33	Incandescent, (1) 33W lamp	33W incandescent		1	33	33	1.5
I34/1	I34	Incandescent, (1) 34W lamp	34W incandescent		1	34	34	1.5
I35/1	I35	Incandescent, (1) 35W lamp	35W incandescent		1	35	35	1.5
I36/1	I36	Incandescent, (1) 36W lamp	36W incandescent		1	36	36	1.5
I37/1	I37	Incandescent, (1) 37W lamp	37W incandescent		1	37	37	1.5
I38/1	I38	Incandescent, (1) 38W lamp	38W incandescent		1	38	38	1.5
I39/1	I39	Incandescent, (1) 39W lamp	39W incandescent		1	39	39	1.5
I40/1	I40	Incandescent, (1) 40W lamp	40W incandescent		1	40	40	1.5
I40E/1	I40/ES	Incandescent, (1) 40W ES lamp	40W incandescent		1	29	29	1.5
I40EL/1	I40/ES/LL	Incandescent, (1) 40W ES/LL lamp	40W incandescent		1	34	34	1.5
I41/1	I41	Incandescent, (1) 41W lamp	41W incandescent		1	41	41	1.5
I42/1	I42	Incandescent, (1) 42W lamp	42W incandescent		1	42	42	1.5
I43/1	I43	Incandescent, (1) 43W lamp	43W incandescent		1	43	43	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
I44/1	I44	Incandescent, (1) 44W lamp	44W incandescent		1	44	44	1.5
I45/1	I45	Incandescent, (1) 45W lamp	45W incandescent		1	45	45	1.5
I46/1	I46	Incandescent, (1) 46W lamp	46W incandescent		1	46	46	1.5
I47/1	I47	Incandescent, (1) 47W lamp	47W incandescent		1	47	47	1.5
I48/1	I48	Incandescent, (1) 48W lamp	48W incandescent		1	48	48	1.5
I49/1	I49	Incandescent, (1) 49W lamp	49W incandescent		1	49	49	1.5
I50/1	I50	Incandescent, (1) 50W lamp	50W incandescent		1	50	50	1.5
I51/1	I51	Incandescent, (1) 51W lamp	51W incandescent		1	51	51	1.5
I52/1	I52	Incandescent, (1) 52W lamp	52W incandescent		1	52	52	1.5
I53/1	I53	Incandescent, (1) 53W lamp	53W incandescent		1	53	53	1.5
I54/1	I54	Incandescent, (1) 54W lamp	54W incandescent		1	54	54	1.5
I55/1	I55	Incandescent, (1) 55W lamp	55W incandescent		1	55	55	1.5
I56/1	I56	Incandescent, (1) 56W lamp	56W incandescent		1	56	56	1.5
I57/1	I57	Incandescent, (1) 57W lamp	57W incandescent		1	57	57	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
I58/1	I58	Incandescent, (1) 58W lamp	58W incandescent		1	58	58	1.5
I59/1	I59	Incandescent, (1) 59W lamp	59W incandescent		1	59	59	1.5
I60/1	I60	Incandescent, (1) 60W lamp	60W incandescent		1	60	60	1.5
I60E/1	I60/ES	Incandescent, (1) 60W ES lamp	60W incandescent		1	43	43	1.5
I60EL/1	I60/ES/LL	Incandescent, (1) 60W ES/LL lamp	60W incandescent		1	52	52	1.5
I61/1	I61	Incandescent, (1) 61W lamp	61W incandescent		1	61	61	1.5
I62/1	I62	Incandescent, (1) 62W lamp	62W incandescent		1	62	62	1.5
I63/1	I63	Incandescent, (1) 63W lamp	63W incandescent		1	63	63	1.5
I64/1	I64	Incandescent, (1) 64W lamp	64W incandescent		1	64	64	1.5
I65/1	I65	Incandescent, (1) 65W lamp	65W incandescent		1	65	65	1.5
I66/1	I66	Incandescent, (1) 66W lamp	66W incandescent		1	66	66	1.5
I67/1	I67	Incandescent, (1) 67W lamp	67W incandescent		1	67	67	1.5
I68/1	I68	Incandescent, (1) 68W lamp	68W incandescent		1	68	68	1.5
I69/1	I69	Incandescent, (1) 69W lamp	69W incandescent		1	69	69	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
I70/1	I70	Incandescent, (1) 70W lamp	70W incandescent		1	70	70	1.5
I71/1	I71	Incandescent, (1) 71W lamp	71W incandescent		1	71	71	1.5
I72/1	I72	Incandescent, (1) 72W lamp	72W incandescent		1	72	72	1.5
I73/1	I73	Incandescent, (1) 73W lamp	73W incandescent		1	73	73	1.5
I74/1	I74	Incandescent, (1) 74W lamp	74W incandescent		1	74	74	1.5
I75/1	I75	Incandescent, (1) 75W lamp	75W incandescent		1	75	75	1.5
I75E/1	I75/ES	Incandescent, (1) 75W ES lamp	75W incandescent		1	53	53	1.5
I75EL/1	I75/ES/LL	Incandescent, (1) 75W ES/LL lamp	75W incandescent		1	67	67	1.5
I80/1	I80	Incandescent, (1) 80W lamp	80W incandescent		1	80	80	1.5
I85/1	I85	Incandescent, (1) 85W lamp	85W incandescent		1	85	85	1.5
I90/1	I90	Incandescent, (1) 90W lamp	90W incandescent		1	90	90	1.5
I93/1	I93	Incandescent, (1) 93W lamp	93W incandescent		1	93	93	1.5
I95/1	I95	Incandescent, (1) 95W lamp	95W incandescent		1	95	95	1.5
I100/1	I100	Incandescent, (1) 100W lamp	100W incandescent		1	100	100	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
I100E/1	I100/ES	Incandescent, (1) 100W ES lamp	100W incandescent		1	72	72	1.5
I100EL/1	I100/ES/LL	Incandescent, (1) 100W ES/LL lamp	100W incandescent		1	90	90	1.5
I110/1	I110	Incandescent, (1) 110W lamp	110W incandescent		1	110	110	1.5
I116/1	I116	Incandescent, (1) 116W lamp	116W incandescent		1	116	116	1.5
I120/1	I120	a	120W incandescent		1	120	120	1.5
I125/1	I125	Incandescent, (1) 125W lamp	125W incandescent		1	125	125	1.5
I130/1	I130	Incandescent, (1) 130W lamp	130W incandescent		1	130	130	1.5
I135/1	I135	Incandescent, (1) 135W lamp	135W incandescent		1	135	135	1.5
I150/1	I150	Incandescent, (1) 150W lamp	150W incandescent		1	150	150	1.5
I150E/1	I150/ES	Incandescent, (1) 150W ES lamp	150W incandescent		1	135	135	1.5
I150EL/1	I150/ES/LL	Incandescent, (1) 150W ES/LL lamp	150W incandescent		1	135	135	1.5
I160/1	I160	Incandescent, (1) 160W lamp	160W incandescent		1	160	160	1.5
I170/1	I170	Incandescent, (1) 170W lamp	170W incandescent		1	170	170	1.5
I200/1	I200	Incandescent, (1) 200W lamp	200W incandescent		1	200	200	1.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
I200L/1	I200/LL	Incandescent, (1) 200W LL lamp	200W incandescent		1	200	200	1.5
I250/1	I250	Incandescent, (1) 250W lamp	250W incandescent		1	250	250	1.5
I300/1	I300	Incandescent, (1) 300W lamp	300W incandescent		1	300	300	1.5
I400/1	I400	Incandescent, (1) 400W lamp	400W incandescent		1	400	400	1.5
I448/1	I448	Incandescent, (1) 448W lamp	448W incandescent		1	448	448	1.5
I500/1	I500	Incandescent, (1) 500W lamp	500W incandescent		1	500	500	1.5
I750/1	I750	Incandescent, (1) 750W lamp	750W incandescent		1	750	750	1.5
I1000/1	I1000	Incandescent, (1) 1000W lamp	1000W incandescent		1	1000	1000	1.5
I1500/1	I1500	Incandescent, (1) 1500W lamp	1500W incandescent		1	1500	1500	1.5
I2000/1	I2000	Incandescent, (1) 2000W lamp	2000W incandescent		1	2000	2000	1.5
MH		Metal Halide Fixtures - Standard, Pulse Start, or Ceramic						
MH20/1-L	MH20	Metal Halide, (1) 20W lamp	20W Metal Halide	Electronic	1	20	23	15.5
MH22/1-L	MH22	Metal Halide, (1) 22W lamp	22W Metal Halide	Electronic	1	22	26	15.5
MH32/1	MH32	Metal Halide, (1) 32W lamp, Magnetic ballast	32W Metal Halide	Magnetic	1	32	42	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
MH39/1	MH39	Metal Halide, (1) 39W lamp, Magnetic ballast	39W Metal Halide	Magnetic	1	39	51	15.5
MH39/1-L	MH39	Metal Halide, (1) 39W lamp	39W Metal Halide	Electronic	1	39	44	15.5
MH50/1	MH50	Metal Halide, (1) 50W lamp, Magnetic ballast	50W Metal Halide	Magnetic	1	50	64	15.5
MH50/1-L	MH50	Metal Halide, (1) 50W lamp	50W Metal Halide	Electronic	1	50	56	15.5
MH70/1	MH70	Metal Halide, (1) 70W lamp, Magnetic ballast	70W Metal Halide	Magnetic	1	70	91	15.5
MH70/1-L	MH70	Metal Halide, (1) 70W lamp	70W Metal Halide	Electronic	1	70	78	15.5
MH100/1	MH100	Metal Halide, (1) 100W lamp, Magnetic ballast	100W Metal Halide	Magnetic	1	100	124	15.5
MH100/1-L	MH100	Metal Halide, (1) 100W lamp	100W Metal Halide	Electronic	1	100	108	15.5
MH125/1	MH125	Metal Halide, (1) 125W lamp, Magnetic ballast	125W Metal Halide	Magnetic	1	125	148	15.5
MH150/1	MH150	Metal Halide, (1) 150W lamp, Magnetic ballast	150W Metal Halide	Magnetic	1	150	183	15.5
MH150/1-L	MH150	Metal Halide, (1) 150W lamp	150W Metal Halide	Electronic	1	150	163	15.5
MH175/1	MH175	Metal Halide, (1) 175W lamp, Magnetic ballast	175W Metal Halide	Magnetic	1	175	208	15.5
MH175/1-L	MH175	Metal Halide, (1) 175W lamp	175W Metal Halide	Electronic	1	175	196	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
MH200/1	MH200	Metal Halide, (1) 200W lamp, Magnetic ballast	200W Metal Halide	Magnetic	1	200	228	15.5
MH200/1-L	MH200	Metal Halide, (1) 200W lamp	200W Metal Halide	Electronic	1	200	219	15.5
MH250/1	MH250	Metal Halide, (1) 250W lamp, Magnetic ballast	250W Metal Halide	Magnetic	1	250	288	15.5
MH250/1-L	MH250	Metal Halide, (1) 250W lamp	250W Metal Halide	Electronic	1	250	275	15.5
MH320/1	MH320	Metal Halide, (1) 320W lamp, Magnetic ballast	320W Metal Halide	Magnetic	1	320	362	15.5
MH320/1-L	MH320	Metal Halide, (1) 320W lamp	320W Metal Halide	Electronic	1	320	343	15.5
MH350/1	MH350	Metal Halide, (1) 350W lamp, Magnetic ballast	350W Metal Halide	Magnetic	1	350	391	15.5
MH350/1-L	MH350	Metal Halide, (1) 350W lamp	350W Metal Halide	Electronic	1	350	375	15.5
MH360/1	MH360	Metal Halide, (1) 360W lamp, Magnetic ballast	360W Metal Halide	Magnetic	1	360	418	15.5
MH400/1	MH400	Metal Halide, (1) 400W lamp, Magnetic ballast	400W Metal Halide	Magnetic	1	400	453	15.5
MH400/1-L	MH400	Metal Halide, (1) 400W lamp	400W Metal Halide	Electronic	1	400	429	15.5
MH450/1	MH450	Metal Halide, (1) 450W lamp, Magnetic ballast	450W Metal Halide	Magnetic	1	450	499	15.5

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
MH450/1-L	MH450	Metal Halide, (1) 450W lamp	450W Metal Halide	Electronic	1	450	486	15.5
MH575/1	MH575	Metal Halide, (1) 575W lamp, Magnetic ballast	575W Metal Halide	Magnetic	1	575	630	15.5
MH750/1	MH750	Metal Halide, (1) 750W lamp, Magnetic ballast	750W Metal Halide	Magnetic	1	750	812	15.5
MH775/1	MH775	Metal Halide, (1) 775W lamp, Magnetic ballast	775W Metal Halide	Magnetic	1	775	843	15.5
MH875/1	MH875	Metal Halide, (1) 875W lamp	875W Metal Halide	Magnetic	1	875	939	15.5
MH1000/1	MH1000	Metal Halide, (1) 1000W lamp, Magnetic ballast	1000W Metal Halide	Magnetic	1	1000	1078	15.5
MH1000/1-L	MH1000	Metal Halide, (1) 1000W lamp	1000W Metal Halide	Electronic	1	1000	1067	15.5
MH1500/1	MH1500	Metal Halide, (1) 1500W lamp, Magnetic ballast	1500W Metal Halide	Magnetic	1	1500	1605	15.5
MH1650/1	MH1650	Metal Halide, (1) 1650W lamp	1650W Metal Halide	Magnetic	1	1650	1765	15.5
MH2000/1	MH2000	Metal Halide, (1) 2000W lamp	2000W Metal Halide	Magnetic	1	2000	2140	15.5
MV		Mercury Vapor Fixtures						

Fixture Code	LAMP CODE	DESCRIPTION	Layman Term	BALLAST	LAMP / FIXT	W / LAMP	W / FIXT	EUL
MV40/1	MV40	Mercury Vapor, (1) 40W lamp	40W Mercury Vapor		1	40	50	15.5
MV50/1	MV50	Mercury Vapor, (1) 50W lamp	50W Mercury Vapor		1	50	74	15.5
MV75/1	MV75	Mercury Vapor, (1) 75W lamp	75W Mercury Vapor		1	75	93	15.5
MV100/1	MV100	Mercury Vapor, (1) 100W lamp	100W Mercury Vapor		1	100	125	15.5
MV160/1	MV160-SB	Mercury Vapor, Self-Ballasted, (1) 160W self-ballasted lamp	160W Mercury Vapor		1	160	160	15.5
MV175/1	MV175	Mercury Vapor, (1) 175W lamp	175W Mercury Vapor		1	175	205	15.5
MV250/1	MV250	Mercury Vapor, (1) 250W lamp	250W Mercury Vapor		1	250	290	15.5
MV400/1	MV400	Mercury Vapor, (1) 400W lamp	400W Mercury Vapor		1	400	455	15.5
MV700/1	MV700	Mercury Vapor, (1) 700W lamp	700W Mercury Vapor		1	700	780	15.5
MV1000/1	MV1000	Mercury Vapor, (1) 1000W lamp	1000W Mercury Vapor		1	1000	1075	15.5

F. Appendix B: References

F.1.1. New Construction

F.1.1.1. References

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F.1.2. Retrocomissioning

F.1.2.1. References

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F.1.2.3. EUL Model Results

				PY1	PY2	PY3	PY4	PY5	PY6	PY7	PY8	PY9	PY10	PY11	PY12	PY13	PY14	PY15	PY16	PY17	PY18	PY19	PY20	
EUL (uncapped)	**Measure**	**slope yr 1**	**slope other yrs**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
3.76	**Air distribution**	0.155	0.153	1.00	0.85	0.69	0.54	0.38	0.23	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.17	**Plant optimization**	0.155	0.040	1.00	0.87	0.69	0.65	0.61	0.57	0.53	0.49	0.45	0.41	0.37	0.33	0.29	0.25	0.21	0.17	0.13	0.09	0.05	0.01	0.00
5.39	**Ventilation**	0.050	0.137	1.00	0.96	0.90	0.76	0.63	0.49	0.35	0.22	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.65	**Scheduling**	0.120	0.007	1.00	0.89	0.76	0.75	0.75	0.74	0.73	0.73	0.72	0.71	0.71	0.70	0.69	0.69	0.68	0.67	0.67	0.66	0.65	0.65	0.64
28.68	**Filters**	0.270	-0.180	1.00	0.76	0.46	0.64	0.82	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.13	**General**	0.025	0.123	1.00	0.98	0.95	0.83	0.70	0.58	0.46	0.33	0.21	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Measure	***Persistence (1-3)***	***Persistence (4-7)***	***Persistence (8+)***	***EUL Uncapped***	***EUL Capped (yr 7)***
Air distribution	2.54	1.23	0.00	3.76	**3.76**
Plant optimization	2.56	2.36	3.25	8.17	**4.92**
Ventilation	2.86	2.23	0.30	5.39	**5.09**
Scheduling	2.65	2.97	15.03	20.65	**5.62**
Filters	2.22	3.46	23.00	28.68	**5.68**
General	2.93	2.57	0.63	6.13	**5.50**