Public Utility Commission of Texas

Texas Technical Reference Manual

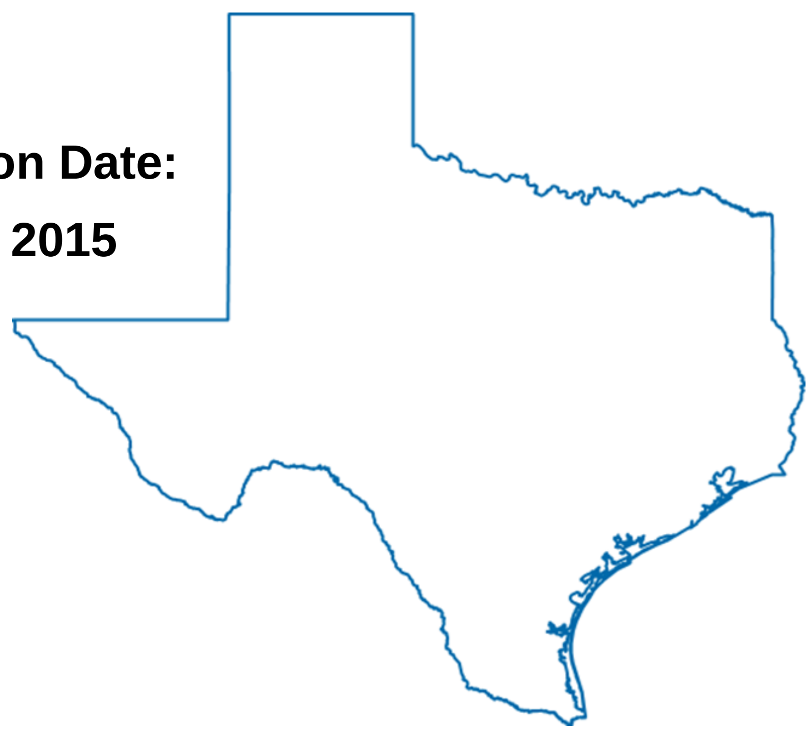
Version 2.1

Volume 3: Nonresidential Measures

Guide for PY2015 Implementation

Last Revision Date:

January 30, 2015



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Acknowledgements

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This version of the Texas Technical Reference Manual was primarily developed from program documentation and measure savings calculators used by the Texas Electric Utilities and their Energy Efficiency Services Providers (EESPs) to support their energy efficiency efforts, and original source material from petitions filed with the Public Utility Commission of Texas by the utilities, their consultants and EESPs such as Frontier Associates, ICF, CLEAResult and Nexant. Portions of the Technical Reference Manual are copyrighted 2001-2013 by the Electric Utility Marketing Managers of Texas (EUMMOT), while other portions are copyrighted 2001-2013 by Frontier Associates. Certain technical content and updates were added by the EM&V team to provide further explanation and direction as well as consistent structure and level of information.

TRM Technical Support

Technical support and questions can be emailed to: TexasTRM@tetratech.com

1. INTRODUCTION

This volume of the TRM contains the deemed savings for nonresidential measures that have been approved for use in Texas by the PUCT. This volume includes instructions regarding various savings calculators and reference sources of the information. The TRM serves as a centralized source of deemed savings values; where appropriate, Measurement & Verification (M&V) methods by measure category are noted for informational purposes only regarding the basis of projected and claimed savings.

Table 1-1 provides an overview of the nonresidential measures contained within Volume 3 and the types of deemed savings estimates available for each one. There are four types of deemed savings estimates identified:

- Point estimates that provide a single deemed savings value that correspond to a single measure or type of technology.
- Deemed saving tables that provide energy and peak savings as a function of size, capacity; building type, efficiency level, or other inputs.
- Savings algorithms that require user defined inputs that must be gathered on site and the identification of default inputs where primary data could not be collected. In many cases, these algorithms are provided as references to deemed savings tables, point estimates, or calculator explanations.
- Calculators are used by different utilities and implementers to calculate energy savings for different measures. In many cases, there are several different calculators available for a single measure. Sometimes their background calculators are similar, and in other cases, estimates can vary greatly between each calculator.

M&V methods are also used for some measures to calculate savings in the event that standard equipment is not used, or the specified building types do not apply. For some of these measures, both a simplified M&V approach and a full M&V approach may be allowed by the utility. M&V methods as a source of claimed and projected savings are noted for informational purposes only.

Please consult Volume I: Overview and User Guide, Section 4: Structure and Content, for details on the organization of the measure templates presented in this volume.

Table 1-1: Nonresidential Deemed Savings by Measure Category

Measure Category	Measure Description	Point Estimates	Deemed Savings Tables	Savings Algorithm	Calculator	M&V	2.1 Update
Lighting	Lighting - Lamps and Fixtures	--	--	X	X	X	--
Lighting	Lighting Controls	--	--	X	X	X	Corrections to Equation 5 through Equation 6 to accurately reflect the energy and power adjustment factors and to reflect savings based on connected load rather than a delta load. Consolidation of algorithms for Retrofit and New Construction projects.
HVAC (Cooling)	Package and Split-System (AC and Heat Pumps)	--	--	X	X	X	Minor text updates and clarification of early retirement requirements.
HVAC (Cooling)	Chillers	--	--	X	X	X	Minor text updates and clarification of early retirement requirements.
HVAC (Cooling)	Package Terminal Units and Room Air Conditioners (AC and Heat Pumps)	--	--	X	X	X	Corrections to energy and demand coefficients for heat pumps in Climate Zone 3 (Houston); Table 2-37.
HVAC (Ventilation)	VFDs on AHU Supply Fans	--	X	X	--	--	--
Building Envelope	Cool Roof	X	--	X	X	--	--
Building Envelope	Window Films and Solar Screens	X	--	X	X	--	--
Food Service	High Efficiency Electric Combination Ovens	--	X	X	--	--	--
Food Service	High Efficiency Electric Convection Ovens	--	X	X	--	--	--
Food Service	ENERGY STAR® Commercial Dishwashers	--	X	X	--	--	Corrections to Water Use per Rack in Table 2-63.
Food Service	ENERGY STAR® Commercial Electric Hot Food Holding Cabinets	--	X	X	--	--	--
Food Service	ENERGY STAR® Kitchen Electric Fryers	--	X	X	--	--	--

Food Service	Pre-Rinse Spray Valves	--	X	X	--	--	--
Food Service	ENERGY STAR® Electric Steam Cookers	--	X	X	--	--	--
Refrigeration	Door Heater Controls	--	X	X	--	--	Correction to state that savings are on a per-linear foot of display case.
Refrigeration	ECM Evaporator Fan Motors	--	--	X	--	--	--
Refrigeration	Electronic Defrost Control	--	--	X	--	--	--
Refrigeration	Evaporator Fan Controls	--	--	X	--	--	--
Refrigeration	Night Covers for Open Refrigerated Cases	--	X	X	--	--	--
Refrigeration	High-Efficiency Solid & Glass Door Reach-in Cases	--	--	X	--	--	--
Refrigeration	Strip Curtains for Walk-in Cooler/Freezer	--	X	--	--	--	--
Refrigeration	Low/No Anti-sweat Heat Glass Doors (Zero Energy Glass Doors)	--	X	X	--	--	--
Miscellaneous	Vending Machine Controllers	--	X	X	--	--	--
Miscellaneous	Lodging Guest Room Occupancy Sensor Control	--	X	--	--	--	--
Miscellaneous	Pump-Off Controller	--	X	X	--	--	TRM v2.1 origin
Solar Electric	Solar Photovoltaics	--	--	X	--	X	--
Demand Response	Load Curtailment Options	--	--	--	--	X	--

2. NONRESIDENTIAL MEASURES

2.1 NONRESIDENTIAL: LIGHTING

2.1.1 Lamps and Fixtures Measure Overview

TRM Measure ID: NR- LT-LF[1]

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All Commercial, Multifamily common areas

Fuels Affected: Electricity (Interactive HVAC effects: Electric/Gas space heating)

Decision/Action Types: Retrofit (RET) and New Construction (NC)

Program Delivery Type: Prescriptive, Custom, Direct Install

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Calculator

Measure Description

This section provides estimates of the energy and peak savings resulting from the retrofit, replacement, or new installation of existing lamps and/or ballasts with new energy efficient lamps and/or ballasts. This TRM Measure ID covers the following lighting technologies:

- Linear Fluorescent T5s, and High-Performance or Reduced Watt T8s. Linear fluorescent measures may also involve delamping[2] with or without the use of reflectors.
- CFLs (Compact Fluorescent lamps) with hardwired ballasts, locking mechanisms, or permanent socket conversions
- Induction lamps
- Pulse-start (PSMH) and Ceramic Metal Halide (CMH) lamps, and other High Intensity Discharge (HID) lamps.
- LED (Light emitting diode) Lamps and fixtures

Energy and demand savings are based on operating hours, coincident-load factors, and changes in pre-existing and post-installation lighting loads as determined using an approved lighting *Standard Fixture Wattage* table (see the *Lighting Survey Form*[3]*).* The *Lighting Survey Form (LSF)* is one example of a calculator that is used to determine energy and demand

[1] The letter codes used to identify measure sector, end use, and measure category are described in Table 4-2 in TRM Volume I.

[2] Delamping energy savings are eligible if done in conjunction with T-8 lamp and electronic ballast retrofits.

[3] Maintained by Frontier/EUMMOT: http://www.texasefficiency.com/images/documents/lsf_2013_v8.01_250%20rows.xlsm

savings. Pre and post-retrofit lighting inventories are entered and used with the pre-loaded stipulated values and algorithms needed to calculate energy and demand savings. Components of the calculator include:

- Instructions and Project Information
- Pre and Post-retrofit lighting inventories. A tab for exempt fixtures, and a description of the exemptions, is also present in this calculator.
- Fixture descriptions are selected from a Standard Fixture Wattage table.
- Factor Tables which contain stipulated operating hours, coincidence factors, and interactive HVAC factors.
- A Summary tab, where the final energy and demand calculations are displayed. The data from this tab is entered into the utility program tracking data as the claimed savings values.

Although the generic *Lighting Survey Form* calculator is available to all entities on the Texas Energy Efficiency website, several utilities have their own versions.

Eligibility Criteria

This section describes the system information and certified wattage values that must be used to estimate energy and peak savings from lighting systems installed as part of the Texas utility energy efficiency programs. The fixture codes and the demand values listed in the Table of Standard Fixture Wattages are used in calculating energy and demand savings for lighting efficiency projects. In addition, LED and linear fluorescent T8s need to be certified, as follows:

High-performance (HP) and reduced-watt (RW) T8 linear fluorescent lamps and ballasts need to be certified by the *Consortium for Energy Efficiency* (CEE). Links for both HPT8s and RWT8s are provided on the Texas Energy Efficiency website[4].

LED lamps and fixtures need to be certified by *Design Lights Consortium* or *ENERGY STAR®*. Links for this equipment are also available on the Texas Energy Efficiency website.

Exempt Lighting for New Construction. Some types of new construction lighting fixtures are exempt from inclusion in the interior lighting demand savings calculation, but they are still included in the total installed lighting power calculations for a project. Exempt fixtures are those that do not provide general/ambient/area lighting, have separate control devices, and are installed in one of the following applications[5]:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
    - 1.1. Professional sports arena playing-field lighting.
    - 1.2. Sleeping-unit lighting in hotels, motels, boarding houses, or similar buildings.

[4] Links to the CEE T8 and LED performance certification organizations can be found on this page: http://www.texasefficiency.com/index.php/regulatory-filings/lighting.

[5] IECC 2009, Section 505.5.1

    1.3. Emergency lighting automatically off during normal building operation.

    1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical and age-related issues.

    1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.

    1.6. Casino gaming areas.

2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:

    2.1. Task lighting for medical and dental purposes.

    2.2. Display lighting for exhibits in galleries, museums, and monuments.

3. Lighting for theatrical purposes, including performance, stage, film production, and video production.

4. Lighting for photographic processes.

5. Lighting integral to equipment or instrumentation and installed by the manufacturer.

6. Task lighting for plant growth or maintenance.

7. Advertising signage or directional signage.

8. In restaurant building and areas, lighting for food warming or integral to food preparation equipment.

9. Lighting equipment that is for sale.

10. Lighting demonstration equipment in education facilities.

11. Lighting approved because of safety or emergency considerations, inclusive of exit lights.

12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.

13. Lighting in retail display windows, provided the display area is enclosed by ceiling height partitions.

14. Furniture-mounted supplemental task lighting that is controlled by automatic shut off.

Baseline Condition

The baseline condition or assumed baseline efficiency used in the savings calculations depends on the decision type used for the measure. For new construction, the baseline will be based on a Lighting Power Density (LPD) in watts/ square foot by building type, as specified by the relevant energy code/standard. For *retrofit* applications, the baseline efficiency would typically reflect the in-situ, pre-existing equipment. Fixture wattages used for the savings calculations are determined from the Table of Standard Fixture Wattages.

Linear Fluorescent T12 Special Conditions

The U.S. Energy Policy Act of 1992 (EPACT) set energy efficiency standards that preclude certain lamps and ballasts from being manufactured or imported into the U.S. On July14, 2012, the latest standards covering general service linear fluorescents went into effect. Under this provision, almost all 4-foot and some 8-foot T12 lamps were prohibited from manufacture. The standard also affected first-generation, 4-foot, 700 series T8 lamps, however, an extension was granted and they will not be phased out until July 2014. Because all lighting equipment for Texas energy efficiency programs must be EPACT compliant, including existing or baseline equipment, adjustments were made to the T12 fixtures in the Standard Fixture Wattage table. Certain T12 lamp/ballast combinations which are non-EPACT compliant are assigned EPACT demand values. Thus, a 4-foot fixture with 40-watt T12 lamps and standard magnetic ballast has the same demand value as a like fixture equipped with 34-watt T12 lamps and energy-efficient magnetic ballast.[6]

High-Efficiency Condition

Acceptable efficient fixture types are specified in the Table of Standard Fixture Wattages. In addition, as explained under Eligibility Criteria, some technologies such as LEDs must be ENERGY STAR® labeled equipment.

High-Efficiency/Performance Linear Fluorescent T8s/T12s

In 2011, the investor-owned utilities of Texas made PUCT-approved changes to the rules and requirements for lighting incentives. As of January 1, 2012, post-retrofit systems using T12 electronic ballasts or standard T8 electronic ballasts are **not** eligible for incentives.

All post-retrofit technologies and new construction must use Reduced Wattage T8 systems or High Performance T8 systems that meet the High Performance and Reduced Wattage lamp and ballast efficiency specifications developed by the Consortium for Energy Efficiency (CEE) as published on its website. This is a requirement for all T8 system retrofits.

In addition, if CEE does not have efficiency guidelines for a T8 system (such as for 8-foot, 3-foot, 2-foot, and U-bend T8 products), the product must have higher light output or reduced wattage than its standard equivalent product, while also providing a higher CRI (color rendition index), a higher rated lamp life, and an equivalent or higher initial and mean lumen output per lamp.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for all lighting projects. The savings are calculated in separate methods for retrofit projects and new construction projects, and both are described below.

6 A similar approach may need to be used when 700 series T8s are phased out in 2014.

Retrofit[7]:

$$\boldsymbol{Energy\ Savings} = (\boldsymbol{kW_{pre}} - \boldsymbol{kW_{installed}}) \times \boldsymbol{Hours} \times (\boldsymbol{HVAC_{energy}})$$

Equation 1

$$\boldsymbol{Peak\ Summer\ Demand\ Savings} = (\boldsymbol{kW_{pre}} - \boldsymbol{kW_{installed}}) \times \boldsymbol{CF} \times (\boldsymbol{HVAC_{demand}})$$

Equation 2

New Construction:

$$\boldsymbol{Energy\ Savings} = \left(\frac{\boldsymbol{LPD} \times \boldsymbol{FloorArea}}{\boldsymbol{1000}} - \boldsymbol{kW_{installed}}\right) \times \boldsymbol{Hours} \times (\boldsymbol{HVAC_{energy}})$$

Equation 3

$$\boldsymbol{Peak\ Summer\ Demand\ Savings} = \left(\frac{\boldsymbol{LPD} \times \boldsymbol{FloorArea}}{\boldsymbol{1000}} - \boldsymbol{kW_{installed}}\right) \times \boldsymbol{CF} \times (\boldsymbol{HVAC_{demand}})$$

Equation 4

Where:

kW_{pre}	=	*Total kW of existing measure (Fixture wattage from Standard wattage table multiplied by quantity of fixtures)*
$kW_{installed}$	=	*Total kW of retrofit measure (Fixture wattage from Standard wattage table multiplied by quantity of fixtures)*
LPD	=	*Acceptable Lighting Power Density based on building type from efficiency codes from Table 2-1 ([W/ft^2]*
Floor Area	=	*Floor area of the treated space where the lights were installed*
Hours	=	*Hours by building type from Table 2-2*
CF	=	*Coincidence factor by building type from Table 2-2*
$HVAC_{energy}$	=	*Energy Interactive HVAC factor by building type*
$HVAC_{demand}$	=	*Demand Interactive HVAC factor by building type*

Each of the parameters in these equations, and the approach or their stipulated values, is discussed in detail below.

[7] For non-operating fixtures, the baseline demand may be adjusted by using values from the Standard Wattage Table. The number of non-operating fixtures will be limited to 10% of the total fixture count per facility.

Lamp and Fixture Wattages (kWpre, kWinstalled)

Existing Construction: Standard Fixture Wattage Table. One example of a Table of Standard Fixture Wattages can be found in the *Lighting Survey Form* maintained on the Texas Energy Efficiency website[8]. This table is used to assign identification codes and demand values (watts) to common fixture types (fluorescent, incandescent, HID, LED, etc.) used in commercial applications. The table is subdivided into lamp types such as linear fluorescent, compact fluorescent, mercury vapor, etc., with each subdivision sorted by fixture code. Each record, or row, in the Table contains a fixture code, which serves as a unique identifier. A legend explains the rules behind the fixture codes.

Each record also includes a description of the fixture, the number of lamps, the number of ballasts if applicable, and the fixture wattage. The table wattage values for each fixture type are averages of various manufacturers' laboratory tests performed to ANSI test standards. By using standardized demand values for each fixture type, the Table simplifies the accounting procedures for lighting equipment retrofits. The table is usually updated periodically as new fixtures are added.

The fixture codes and the demand values listed in the watt/fixture column in the Table of Standard Fixture Wattages are used in calculating energy and demand savings for any lighting efficiency project. There are two versions of the Table of Standard Fixture Wattages (Frontier and Nexant). Having a common master table in a single location would make it easier to maintain and add new fixtures, and more importantly ensure consistent savings are used for the same lighting measure across the state. However, an alternative approach would be to compare all standard wattage tables being used as part of the evaluation effort, identify differences, and choose the one that is most correct.

For implementers interested in adding new fixtures to Frontier's lighting table, a request should be submitted to Frontier. The request should include all information required to uniquely identify the fixture type and to fix its demand, as well as other contextual information needed for the table. If possible, the request should also be supported by manufacturer's ANSI test data. Frontier then periodically releases updates of the table.

New Construction: Lighting Power Density Table. For new construction projects, the post-retrofit lighting wattages are determined as they are for the existing construction projects, from the Standard Fixture Wattage table. However, the baseline wattage is determined from the treated floor area and a lighting power density (LPD) value, which are the allowable watts per square foot of lit floor area as specified by the relevant energy code. These values are presented in Table 2-1.

[8] Frontier Associates *Lighting Survey Form*, *Fixture Description* tab: http://www.texasefficiency.com/images/documents/lsf_2013_v8.01_250%20rows.xlsm.

Table 2-1: New Construction LPDs by Building Type[9]

Facility Type	Lighting Power Density (W/ft^2)	Facility Type	Lighting Power Density (W/ft^2)
Automotive Facility	0.90	Office	1.00
Convention Center	1.20	Outdoor Uncovered Parking Area: Zone 1	0.04
Courthouse	1.20	Outdoor Uncovered Parking Area: Zone 2	0.06
Dining: Bar/Lounge/Leisure	1.30	Outdoor Uncovered Parking Area: Zone 3	0.10
Dining: Cafeteria	1.40	Outdoor Uncovered Parking Area: Zone 4	0.13
Dining: Family	1.60	Parking Garage	0.30
Dormitory	1.00	Penitentiary	1.00
Exercise Center	1.00	Performing Arts	1.60
Gymnasium	1.10	Police/Fire Stations	1.00
Health Care – Clinic	1.00	Post Office	1.10
Hospital	1.20	Religious Buildings	1.30
Hotel	1.00	Retail	1.50
Library	1.30	School/University	1.20
Manufacturing	1.30	Sports Arena	1.10
Motel	1.00	Town Hall	1.10
Motion Picture	1.20	Transportation	1.00
Multi-Family	0.70	Warehouse	0.80
Museum	1.10	Workshop	1.40

In Table 2-1 above, the zones used for the Outdoor Uncovered Parking Areas are:

- **Zone 1:** Developed areas of national parks, state parks, forest lands, and rural areas
- **Zone 2:** Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited night-time use, and residential mixed use areas
- **Zone 3:** All other areas
- **Zone 4:** High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

Operating Hours (Hours) and Coincidence Factors (CFs)

Operating hours and peak demand coincidence factors are assigned by building type, as shown in Table 2-2. The building types used in this table are based on CBECS[10] building types, but have been modified for Texas.

[9] Source per *Lighting Survey Form*: ANSI/ASHRAE/IESNA Standard 90.1 -2007 Table. 9.5.1, p. 62 & IECC 2009 Table. 505.5.2, p. 59.
[10] DOE-EIA Commercial Building Energy Consumption Survey.

Table 2-2: Operating Hours and Coincidence Factors by Building Type[11]

Building Type Code	Building Type Description	Operating Hours	Summer Peak Coincidence Factor
Educ. K-12, No Summer	Education (K-12 w/o Summer Session)	2,777	47%
Education, Summer	Education: College, University, Vocational, Day Care, and K-12 w/ Summer Session	3,577	69%
Non-24 Hour Retail	Food Sales – Non-24 Hour Supermarket/Retail	4,706	95%
24-Hr Retail	24 Hour Supermarket/Retail	6,900	95%
Fast Food	Food Service – Fast Food	6,188	81%
Sit Down Rest.	Food Service – Sit-down Restaurant	4,368	81%
Health In	Health Care (In Patient)	5,730	78%
Health Out	Health Care (Out Patient)	3,386	77%
Lodging, Common	Lodging (Hotel/Motel/Dorm), Common Area	6,630	82%
Lodging, Rooms	Lodging (Hotel/Motel/Dorm), Rooms	3,055	25%
Manufacturing	Manufacturing	5,740	73%
MF Common	Multi-family Housing, Common Areas	4,772	87%
Nursing Home	Nursing and Residential Care	4,271	78%
Office	Office	3,737	77%
Outdoor	Outdoor Lighting Photo-Controlled	3,996	0% (Winter peak = 61%[12])
Parking	Parking Structure	7,884	100%
Public Assembly	Public Assembly	2,638	56%
Public Order	Public Order and Safety	3,472	75%
Religious	Religious Worship	1,824	53%
Retail Non Mall/Strip	Retail (Excl. mall and strip center)	3,668	90%
Enclosed Mall	Retail (Enclosed Mall)	4,813	93%
Strip/Non-Enclosed Mall	Retail (Strip Center and non-enclosed mall)	3,965	90%
Service (Non-Food)	Service (excl. food)	3,406	90%
Non-Refrig. Warehouse	Warehouse (non-refrigerated)	3,501	77%
Refrig. Warehouse	Warehouse (refrigerated)	3,798	84%

Note: These petition-approved values listed in this table come from PUCT Docket 39146. The exception to this is the Winter Peak factor of 61% for Outdoor Lighting (see Footnote 12). Slight variations to these are found in other calculators and program manuals. A set of comparisons of HOU and CF across utilities are found in Appendix C.

[11] Frontier Associates *Lighting Survey Form, Factor Tables* tab on the Texas Energy Efficiency website: *http://www.texasefficiency.com/images/documents/lsf_2013_v8.01_250%20rows.xlsm.*

[12] Outdoor lighting is the only nonresidential lighting measure for which a winter peak demand value has currently been developed and used in some utility calculators. There are currently two values used: Frontier uses 0.61 which was developed to represent a statewide average, and Oncor uses 0.64 which was developed to represent its service area.

Interactive HVAC Factors (HVAC energy, demand)

Basic lighting savings are adjusted to account for the lighting system interaction with HVAC systems in conditioned or refrigerated spaces. A reduced lighting load reduces the internal heat gain to the building, which reduces the air conditioning/cooling load but it also increases the heating load. Currently, TRM 2.0 only considers the additional cooling savings, and the heating penalty or increase in usage is ignored.

As Table 2-3 shows, four conditioned space types are used for the Texas programs. There is a single air-conditioned space type and two options for commercial refrigeration type spaces like walk-in coolers and refrigerated warehouses: Medium and Low temperature. Utility procedures state that if the actual application falls between these values, that the higher temperature value should be used. The final space type is unconditioned (or more explicitly uncooled as the focus is on cooling). In the lighting calculators, these values are typically assigned at the line-item level based on the conditioning type for the space in which the fixtures are located.

Table 2-3: Deemed Energy and Demand Interactive HVAC Factors[13]

Space Conditioning Type	Energy Interactive HVAC Factor	Demand Interactive HVAC Factor
Air Conditioned	1.05	1.10
Med. Temp Refrigeration (33 to 41ºF)	1.25	1.25
Low Temp Refrigeration (-10 to 10ºF)	1.30	1.30
None (Unconditioned/Uncooled)	1.00	1.00

Deemed Energy and Demand Savings Tables

This section is not applicable as these calculations are entirely dependent on site-specific parameters related to lighting system operation.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) values are defined for specific lighting types by the Texas petition process, and are maintained on the Texas Energy Efficiency website and are listed below[14]:

- Halogen Lamps: 1.5 years
- High Intensity Discharge Lamps: 15.5 years
- Integrated-ballast CCFL Lamps: 4.5 years

[13] PUCT Docket 39146. Table 7 (page 17) and Table 12 (page 24).
[14] PUCT Docket 36779.

- Integrated-ballast CFL Lamps: 2.5 years
- Integral LED Lamps: 9 years[15]
- Light Emitting Diode: 15 years
- Modular CFL and CCFL Fixtures: 16 years
- T8 and T5 Linear Fluorescents: 15.5 years
- LEDs or T8 and T5 Linear Fluorescents replacing T12s with magnetic ballasts: 8.5 years[16]

Additional Calculators and Tools

There appear to be at least five different lighting calculators being used for the Texas C&I programs. The calculators are periodically updated and a new version published. A comparison of the key stipulated parameters that are used in the calculators - hours of operation, coincidence factors, energy adjustment factors, and power adjustment factors - is provided in Appendix C. Several variations that may need to be reconciled by future TRM efforts have been identified. The lighting calculators currently being used are described briefly below.

Frontier's Lighting Survey Form Calculator [1 file]. EUMMOT/Frontier maintains a deemed savings calculator for all utilities except Oncor**.** This calculator is available from the Texas Energy Efficiency site[17].The main calculator modes are Retrofit and New Construction. It has multiple tabs to handle the various aspects of the calculations including Exempt fixtures, Standard Fixture Wattage tables, and deemed stipulated values (operating hours, coincidence factors, interactive HVAC&R factors, etc.). The spreadsheet also permits entry of Custom fixtures and building type stipulated values.

Oncor Lighting Calculators [2 files]. Developed and maintained by Oncor. There are two calculators: one for retrofit [*2013- E1 (Lighting Retrofit).xls]* and the other for new construction [*2013-N1(NEW_CONSTRUCTION_ LIGHTING).xlsx]*. Two calculation modes are available: Deemed or M&V mode with the key difference being that hours and coincidence factors are supposed to be derived from measurements for the M&V mode. Lighting controls are also integrated into the calculators. There are separate tabs for Instructions, equipment inventory by usage areas, and operating hours, estimated incentives, and a Standard Wattage table. The new construction calculator is similar in structure, except that a lighting power density (LPD) on a building type basis is used.

Other Miscellaneous Calculators. El Paso Electric has a Small Commercial Lighting Program calculator (*LSF Ms. Comm 5-11-12.xlsm*, maintained by CLEAResult), and SWEPCO has an MTP Direct Install program calculator (*KEMA-DI-Ltg_2012.xlsx*, maintained by DNV GL).

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[15] PUCT Docket 38023.
[16] PUCT Docket 39146. Page 15-16.
[17] Latest version of the Lighting Survey Form available at**:** http://www.texasefficiency.com/index.php/regulatory-filings/lighting

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Baseline Fixture Configuration
- Baseline Lamp Details
- Baseline Ballast Type
- Baseline Lighting Controls
- Baseline Counts of Operating Fixtures
- Baseline Counts of Non-Operating Fixtures
- Post-Retrofit Fixture Configuration
- Post-Retrofit Lamp Details
- Post-Retrofit Ballast Type
- Post-Retrofit Lighting Controls
- Post-Retrofit Counts of Operating Fixtures
- Building Type
- Savings Approach Type
- Conditioned Space Type (% Cooled, %Heated, and heating fuel type)
- Equipment Operating Hours

Lighting measure groups to be used for measure summary reports:

The lighting measure groups below must be used for reporting summarized savings of lighting measures. Higher-level groupings of lighting technologies, such as "NonLED" lighting, will not provide enough resolution for evaluation and cost effectiveness analysis. These lighting groups are consistent with the EULs defined for lighting technologies, and will ensure that the correct, approved EUL can be associated with reported lighting savings.

Table 2-4: Lighting Measure Groups to be used for Reporting Savings

TRM Standard Measure Groups	EUL Measure Description
T8/T5 Linear Fluorescent	T8 and T5 Linear Fluorescent
T8/T5s replacing magnetic ballast T12s	LEDs or T8 and T5 Linear Fluorescents replacing T12s with magnetic ballasts
LEDs replacing magnetic ballast T12s	LEDs or T8 and T5 Linear Fluorescents replacing T12s with magnetic ballasts
Integrated-ballast CCFL Lamps	Integrated-ballast CCFL Lamps
Integrated-ballast CFL Lamps	Integrated-ballast CFL Lamps
Modular CFL and CCFL Fixtures	Modular CFL and CCFL Fixtures
Light Emitting Diode (LED)	Light Emitting Diode (LED)
Integral LED Lamp	Integral LED Lamp
High Intensity Discharge (HID)	High Intensity Discharge (HID)
Halogen	Halogen

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Describes Effective Useful Life
- PUCT Docket 39146 – Describes deemed values for energy and demand savings
- PUCT Docket 38023 – Describes LED Installation and Efficiency Standards for non-residential LED products

Relevant Standards and Reference Sources

- DOE's LED Lighting Facts showcases LED products for general illumination from manufacturers who commit to testing products and reporting performance results. http://www1.eere.energy.gov/buildings/ssl/ledlightingfacts.html. Accessed 09/19/2013.
- ENERGY STAR® requirements for Commercial LED Lighting. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LTG. Accessed 09/19/2013.
- Design Lights Consortium. www.designlights.org. Accessed 09/19/2013.
- CEE Guidelines for eligible T8 measures. www.cee1.org. Accessed 09/19/2013.
- U.S. Lighting Market Characterization report, September 2002, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lmc_vol1_final.pdf. Accessed 9/19/2013.
- United Illuminating Company and Connecticut Light & Power. Final Report, 2005 Coincidence Factor Study.

http://webapps.cee1.org/sites/default/files/library/8828/CEE_Eval_CTCoincidenceFactorsC&ILightsHVAC_4Jan2007.PDF. Accessed 09/19/2013.

Document Revision History

Table 2-5: Nonresidential Lighting-Lamps and Fixtures Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	*Measure Life section*: Added additional energy efficiency measures for consistency with the EUMMOT maintained list. *Calculator and Tools section*: Eliminated description of calculator output comparisons. *Tracking Data Requirements section:* Added lighting category requirements for measure summary reports.

2.1.2 Lighting Controls Measure Overview

TRM Measure ID: NR-LT-LC

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All Commercial, Multifamily common areas

Fuels Affected: Electricity (Interactive HVAC effects: Electric/Gas space heating)

Decision/Action Types: Retrofit (RET), New Construction (NC)

Program Delivery Type: Prescriptive, Custom, Direct Install

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Calculator

<u>Measure Description</u>

This measure promotes the installation of lighting controls in both new construction and retrofit applications. For retrofit applications, lighting controls would typically be installed where there is no control other than a manual switch (wall or circuit panel). For new construction lighting systems, they would be added where they are not already required by existing energy or building codes. Promoted technologies include occupancy sensors and daylight dimming controls. Energy and peak demand savings are calculated for these technologies via an energy adjustment factor (EAF[18]) for kWh, and a power adjustment factor (PAF) for kW.

Eligibility Criteria

Measures installed through utility programs must be one of the occupancy sensor or daylighting controls that are described in the adjustment factor tables.

Baseline Condition

The baseline condition assumes no existing or code required (new construction) lighting controls. (e.g. No control equipment in the baseline).

High-Efficiency Condition

The energy-efficient condition is properly installed and calibrated lighting controls that control overhead lighting in a facility based on occupancy or day lighting sensors.

[18] The Oncor July 2013 TRM includes this note about the EAF “Joint Petitioners propose the use of the term Energy Adjustment Factor (EAF) for determining the energy (kWh) impacts of controls and Power Adjustment Factor (PAF) for determining the demand (kW) impacts of controls. The unit of electrical power is the watt (kW = 1000 watts) while kWh is a unit of energy and a product of both power and time in hours.”

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The equations for lighting controls are the same as those used for lighting lamps and fixtures, with the addition of the EAF and PAF multipliers, as shown below.

$$\boldsymbol{Energy\ Savings = kW_{controlled} \times (1 - EAF) \times Hours \times (HVAC_{energy})}$$

Equation 5

$$\boldsymbol{Peak\ Summer\ Demand\ Savings = kW_{controlled} \times (1 - PAF) \times CF \times (HVAC_{demand})}$$

Equation 6

Where:

$kW_{controlled}$	=	*Total kW of controlled fixtures (Fixture wattage from Standard wattage table multiplied by quantity of fixtures)*
Hours	=	*Hours by building type from Table 2-2*
EAF	=	*Lighting control Energy Adjustment Factor from Table 2-6*
PAF	=	*Lighting control Power Adjustment Factor from Table 2-6*
CF	=	*Coincidence factor by building type from Table 2-2*
$HVAC_{energy}$	=	*Energy Interactive HVAC factor by building type, Table 2-3*
$HVAC_{demand}$	=	*Demand Interactive HVAC factor by building type, Table 2-3*

See the 2.1.1 *Lighting – Lamps and Fixtures* measure for an explanation of the non-control variables. The lighting controls peak PAFs and EAFs for different building types are represented in the Table 2-6. The EAF and PAF account for the reduction in on-time, for example a factor of 0.90 means the lights are on 90% of the pre-retrofit operating hours, which is equivalent to a 10% reduction in pre-retrofit on-time.

Table 2-6: Lighting Controls Energy and Power Adjustment Factors[19]

Control Type (DC = Daylight Controls)	EAF and PAF Control Codes	Energy Adjustment Factor (EAF)	Power Adjustment Factor (PAF)	
		All Building Types	K-12 (No-Summer Bldgs)	Remaining Bldgs
No controls measures	None	1.00	1.00	1.00
Stipulated DC – continuous dimming	DC-cont	0.70	0.76	0.70
Stipulated DC – multiple step dimming	DC-step	0.80	0.84	0.80
Stipulated DC – ON/OFF (Indoor)	Indoor DC-on/off	0.90	0.92	0.90
Stipulated DC – ON/OFF (Outdoor)	Outdoor DC-on/off	1.00	1.00	1.00
Stipulated Occupancy Sensor	OS	0.70	0.80	0.75
Stipulated OS w/DC – continuous	OS-cont	0.60	0.72	0.65
Stipulated OS w/DC – multiple step	OS-step	0.65	0.76	0.70
Stipulated OS w/DC – ON/OFF	OS-on/off	0.65	0.76	0.70

Deemed Energy and Demand Savings Tables

N/A

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for lighting controls is provided by the 2007 GDS Associates Report[20]:

- Occupancy Sensor: 10 years
- Photocell (Daylighting Control): 10 years
- Timeclock: 10 years

[19] These values come from Petition 40668. The EAFs are sourced from ASHRAE 90.1-1989 Section 6.4.3. The PAFs provided in the petition are engineering estimates.

[20] GDS Associates. Measure Life Report – Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for the New England State Program Working Group (SPWG). June 2007. This report only specifies an EUL for Occupancy Sensors and Photocells, so it is assumed that the same EUL was applied to time clocks.

Additional Calculators and Tools

Lighting control factors are fully integrated into the lighting calculators, which are discussed in Section 2.1.1 *Lighting – Lamps and Fixtures* measure.

Program Tracking Data & Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Building Type
- Site Floor Area
- Baseline Lighting Control Type
- Post-Retrofit Lighting Control Type
- Existing Fixture Configuration
- Existing Fixture Lamp Type
- Existing Fixture Wattage

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40668 – Describes deemed values to be used in energy and demand savings calculations.
- PUCT Docket 36779 – Describes Effective Useful Life

Relevant Standards and Reference Sources

- 2009 IECC (Commercial buildings)
- ASHRAE 90.1-2010 (Public/State buildings)
- ANSI/ASHRAE/IESNA Standard 90.1 -2007

Document Revision History

Table 2-7: Nonresidential Lighting Controls Revision History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.1	01/30/2015	Corrections to Equation 5 and Equation 6 to accurately reflect the energy and power adjustment factors and to reflect savings based on connected load rather than a delta load. Consolidation of algorithms for Retrofit and New Construction projects.

2.2 NONRESIDENTIAL: HVAC

2.2.1 Split System/Single Packaged Heat Pumps and Air Conditioners Measure Overview

TRM Measure ID: NR-HV-PS

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 2-12 through Table 2-16

Fuels Affected: Electricity

Decision/Action Type: Replace-on-Burnout (ROB), Early Retirement (ER), and New Construction (NC)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Calculator

Measure Description

This section summarizes the deemed savings methodology for the installation of air-cooled Split System and Single Packaged Air Conditioning and Heat Pump systems. This document covers assumptions made for baseline equipment efficiencies for early retirement (ER) based on the age of the replaced equipment, and replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards. It also provides estimates of baseline equipment efficiencies in the event that the actual age of the unit is unknown.

Applicable efficient measure types include:[21]

- Packaged and Split air conditioners (DX or air-cooled)
- Packaged and Split heat pumps (air-cooled)

Eligibility Criteria

For a measure to be eligible to use this deemed savings approach, the following conditions must be met:

- The existing and proposed cooling equipment are electric.

[21] Savings can also be claimed for a retrofit involving a change in equipment type (i.e. Air cooled packaged DX system to a water-cooled centrifugal chiller, or a split system air cooled heat pump to an air-cooled non-centrifugal chiller). In the event that this type of retrofit is performed, the tables from the following HVAC measure templates will need to be referenced:

- HVAC – Chillers
- HVAC – Split System/Single Packaged Heat Pumps and Air Conditioners

- The climate zone is determined from the county-to-climate-zone mapping table.
- Coefficients are listed in Table 2-12 through Table 2-16 for the type of building and climate zone in which the retrofit occurs and the type of equipment involved.
- The building falls into one of the categories listed in Table 2-12 through Table 2-16.

Baseline Condition

The baseline conditions related to efficiency and system capacity for early retirement and replace-on-burnout/new construction are as follows:

Early Retirement

Early retirement systems involve the replacement of a working system. The early retirement baseline cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. Baseline efficiency is estimated according to the capacity, distribution system type, and year of manufacture of the replaced system.

When the system age can be determined (from a nameplate, building prints, equipment inventory list, etc.), the baseline efficiency levels provided in Table 2-8 and Table 2-9 should be used. When the system age is unknown, Table 2-10 should be used. Note that Table 2-10 provides failure probability-weighted average efficiency levels by equipment type and *program year*[22].

[22] As noted in Docket 40885, page 14-15: Failure probability weights are established by assuming that systems for which age information will be unavailable are likely to be older, setting a minimum age threshold, and using the survival functions for the relevant system type to estimate the likelihood that an operational system is of a given age beyond that threshold. Baseline efficiency for each year of system age is established relative to program year. Baseline efficiency levels can be estimated for the next ten program years, taking into account increments in efficiency standards that took place in the historical period.

Table 2-8: Early Retirement: Baseline Efficiency of Air Conditioners when System Age is Known

Year Installed (Replaced System)	Split Systems < 5.4 tons [SEER]	Package System < 5.4 tons [SEER]	All Systems 5.4-11.25 tons [EER]	All Systems 11.25-20 tons [EER]	All Systems 20-63.3 tons [EER]	All Systems > 63.3 tons [EER]
≤ 1991[23]	10	9.7	8.9	8	8	7.8
1992 - 2001	10	9.7	8.9	8.3	8.3	8
2002 - 2005	10	9.7	10.1	9.5	9.3	9
2006 - 2009	13	13	10.1	9.5	9.3	9
2010	13	13	11	10.8	9.8	9.5

Note: Intent of filing is that this is updated every few years so that systems greater than 5 years old will be eligible for early retirement.

Table 2-9: Early Retirement: Baseline Cooling Efficiency of Heat Pumps when System Age is Known

Year Installed (Replaced System)	Split Systems < 5.4 tons [SEER]	Package System < 5.4 tons [SEER]	All Systems 5.4-11.25 tons [EER]	All Systems 11.25-20 tons [EER]	All Systems 20-63.3 tons [EER]	All Systems > 63.3 tons [EER]
≤ 1991[24]	10	9.7	8.9	8	8	7.8
1992 - 2001	10	9.7	8.9	8.3	8.3	8.5
2002 – 2005	10	9.7	9.9	9.1	8.8	8.8
2006 - 2009	13	13	9.9	9.1	8.8	8.8
2010	13	13	10.8	10.4	9.3	9.3

Note: Intent of filing is that this is updated every few years so that systems greater than 5 years old will be eligible for early retirement.

[23] PUCT Docket 40083 provides baseline efficiencies for Air Conditioners and Heat Pumps, replaced via early retirement programs, as shown in Table 2-8 and Table 2-9. These baseline efficiencies are only created for systems between 1990 and 2010, yet common practice in Texas is to allow systems older than 1990 to use the same baseline efficiencies as those listed for 1990-1991.

[24] PUCT Docket 40083 provides baseline efficiencies for Air Conditioners and Heat Pumps, replaced via early retirement programs, as shown in Table 2-8 and Table. These baseline efficiencies are only created for systems between 1990 and 2010, yet common practice in Texas is to allow systems older than 1990 to use the same baseline efficiencies as those listed for 1990-1991.

Table 2-10: Early Retirement: Weighted Average Efficiency of Packaged/Split Systems of Undetermined Age

Program Year	Air Conditioning						Heat Pump					
	Split	Packaged	All				Split	Packaged	All			
	< 5.4		5.4-11.25	11.25–20	20–63.3	> 63.3	< 5.4		5.4-11.25	11.25–20	20–63.3	> 63.3
	[SEER]		[EER]				[SEER]		[EER]			
2014	10.0	9.7	9.0	8.4	8.4	8.1	10.0	9.7	9.0	8.4	8.3	8.5
2015	10.0	9.7	9.2	8.6	8.5	8.2	10.0	9.7	9.1	8.5	8.4	8.6
2016	10.0	9.7	9.3	8.7	8.6	8.3	10.0	9.7	9.2	8.6	8.5	8.6
2017	10.0	9.7	9.5	8.9	8.8	8.5	10.0	9.7	9.4	8.7	8.5	8.6
2018	10.3	10.0	9.6	9.0	8.9	8.6	10.3	10.0	9.5	8.8	8.6	8.7
2019	10.7	10.4	9.7	9.1	9.0	8.7	10.7	10.4	9.6	8.9	8.6	8.7
2020	11.0	10.8	9.8	9.2	9.1	8.8	11.0	10.8	9.7	8.9	8.7	8.7
2021	11.4	11.2	9.9	9.3	9.2	8.9	11.4	11.2	9.8	9.0	8.7	8.8
2022	11.8	11.6	10.1	9.5	9.3	9.0	11.8	11.6	9.9	9.2	8.8	8.8

Replace-on-Burnout (ROB) and New Construction (NC):

Baseline efficiency levels for package and split DX air conditioners and heat pumps are provided in Table 2-11**.** These baseline efficiency levels reflect the latest ASHRAE and recently adopted federal manufacturing standards.

Table 2-11: Baseline Efficiency Levels for ROB and NC Air Conditioners and Heat Pumps

System Type	Capacity [Tons]	Baseline Efficiency	Source[25]
Air Conditioner	< 5.4	13 SEER	DOE Standards
	5.4 < 11.25	11 EER	DOE Standards
	11.25 < 20	10.8 EER	DOE Standards
	20 < 63.3	9.8 EER	DOE Standards
	≥ 63.3	9.5 EER	ASHRAE 90.1-2010
Heat Pump (cooling) [26]	< 5.4	13 SEER	DOE Standards
	5.4 < 11.25	10.8 EER	DOE Standards
	11.25 < 20	10.4 EER	DOE Standards
	≥ 20	9.3 EER	ASHRAE 90.1-2010
Heat Pump (heating) [27]	< 5.4	7.7 HSPF	DOE Standards
	5.4 < 11.25	3.3 COP	DOE Standards
	≥ 11.25	3.2 COP	DOE Standards

High-Efficiency Condition

Package and split-systems must exceed the minimum efficiencies specified in Table 2-11. Additional conditions for replace-on-burnout, early retirement and new construction are as follows:

New Construction and Replace on Burnout

The scope of the project for which incentives can be requested is limited to individual pieces of equipment.

Early Retirement

The high-efficiency retrofits must meet the following criteria[28]:

- Must be within 80% to 120% of the replaced electric cooling capacity
- No additional measures are being installed that directly affect the operation of the cooling equipment (i.e., control sequences, cooling towers, and condensers).

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[25] These baseline efficiency standards noted as "DOE Standards" are cited in the Code of Federal Regulations, 10 CFR 431.97.

[26] ASHRAE 90.1-2010 Table 6.8.1A. These systems larger than 5.4 tons, the minimum efficiency levels provided in this table are based on systems with heating type "All Other Types of Heating", excluding systems with "No Heating or Electric Resistance Heating".

[27] Heat pump retrofits should also meet the baseline efficiency levels for heating efficiencies also.

[28] From PUCT Docket #41070.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$Peak\ Demand\ Savings\ (kW) = Tons \times \left(a \times \eta_{baseline} - b \times \eta_{retrofit}\right)$$

Equation 7

$$Energy\ Savings\ (kWh) = Tons \times \left(c \times \eta_{baseline} - d \times \eta_{retrofit}\right)$$

Equation 8

Where:

Tons	=	*Rated equipment cooling capacity at AHRI standard conditions (of the smallest unit to be installed or removed)*
$\eta_{baseline}$	=	*Efficiency of existing equipment (ER) or standard equipment (ROB/NC) (kW/Ton)*
$\eta_{retrofit}$	=	*Rated efficiency of the newly installed equipment (kW/Ton) - (Must exceed baseline efficiency standards in Table 2-11)*
a,b	=	*Demand coefficients for appropriate climate zone, building type, and new and standard equipment types, see Table 2-12 through Table 2-16*
c,d	=	*Energy coefficients for appropriate climate zone, building type, and new and standard equipment types, see Table 2-12 through Table 2-16 (hours)*

Early Retirement Savings

The first year savings algorithms in Equations 9 and 10 are used for all HVAC projects, across NC, ROB, and ER projects. However, ER projects require a weighted savings calculated over both the early retirement period and the replace-on-burnout period, and take into account the EUL and the RUL. The final reported savings for ER projects are not actually a “first-year” savings, but an average annual savings over the lifetime (EUL) of the measure. These savings calculations are explained in Appendix D.

Table 2-8 and Table 2-10 provide baseline efficiency ratings for equipment replaced in early retirement projects. The efficiency ratings are given in terms of SEER or EER and must be converted to kW/ton using the following conversion calculations:

$$\frac{kW}{Ton} = \frac{12}{EER}$$

Equation 9

$$\frac{kW}{Ton} = \frac{12}{SEER \times 0.697 + 2.0394}$$

Equation 10

Table 2-12 through Table 2-16 provide the demand and energy coefficients. These HVAC coefficients vary by climate zone, building type, and equipment type. A description of the calculation method can be found in Docket No. 40885, Attachment B.

Readers' note: The TRM team has recommended that the current full-load efficiency approach be changed to a part-load efficiency approach. If adopted, this change will result in revised algorithms and energy/demand savings coefficients.

Deemed Energy and Demand Savings Tables

Deemed energy and demand savings coefficients have been calculators by building type and climate zone for packaged and split AC and HP units in Table 2-12 through Table 2-16. In some cases, a coefficient may not have been developed for a certain technology, climate zone, and building type combination. In the event that a coefficient has not been created, the specific combination is not allowed as a valid option.

Table 2-12: Demand and Energy Consumption Coefficients for Amarillo (Climate Zone 1)

Building Type	Packaged and Split DX			
	Air Conditioner		Heat Pump	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
Apartment-Midrise	0.80	727	0.80	1,116
Clinic-Out Patient	0.82	2,189	0.82	3,743
College	0.92	1,721	--	--
Convenience	0.92	3,452	--	--
Grocery	0.92	2,252	--	--
Hospital	0.89	3,107	0.89	4,638
Hotel-Large	0.87	1,906	0.87	3,033
Hotel-Small	0.66	1,309	0.66	2,365
Motel	0.92	1,887	--	--
Nursing Home	0.92	1,873	--	--
Office-Large	0.86	1,213	0.86	1,795
Office-Medium	0.73	893	0.73	1,440
Office-Small	0.73	769	0.73	1,171
Public Assembly	0.92	1,797	--	--
Restaurant-Full Service	1.00	1,337	1.00	2,317
Restaurant-Quick Serve	0.95	1,078	0.95	2,124
Religious Worship	0.90	1,585	--	--
Retail-Single	0.78	832	0.78	1,579
School-Primary	0.95	853	0.95	1,626
School-Secondary	0.94	798	0.94	1,495
Service	0.92	1,848	--	--
Strip Mall	0.89	924	0.89	1,710
Supermarket	0.61	800	0.61	1,586
Warehouse	0.62	290	0.62	1,660

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-13: Demand and Energy Consumption Coefficients for Fort Worth (Climate Zone 2)

Building Type	Packaged and Split DX			
	Air Conditioner		Heat Pump	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
Apartment-Midrise	0.90	1,322	0.90	1,606
Clinic-Out Patient	0.88	2,828	0.88	4,329
College	0.91	1,955	--	--
Convenience	0.92	3,831	--	--
Grocery	0.92	2,815	--	--
Hospital	0.98	4,185	0.98	5,534
Hotel-Large	0.96	2,962	0.96	3,836
Hotel-Small	0.85	2,203	0.85	2,948
Motel	0.92	2,211	--	--
Nursing Home	0.92	2,218	--	--
Office-Large	0.91	1,720	0.91	2,123
Office-Medium	0.85	1,281	0.85	1,691
Office-Small	0.91	1,347	0.91	1,568
Public Assembly	0.92	2,385	--	--
Restaurant-Full Service	0.86	1,548	0.86	2,150
Restaurant-Quick Serve	0.87	1,302	0.87	1,773
Religious Worship	0.92	1,946	--	--
Retail-Single	0.87	1,231	0.87	1,653
School-Primary	0.91	1,162	0.91	1,636
School-Secondary	1.00	1,244	1.00	1,641
Service	0.92	2,262	--	--
Strip Mall	0.93	1,288	0.93	1,698
Supermarket	0.85	1,296	0.85	1,918
Warehouse	0.89	622	0.89	1,567

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-14: Demand and Energy Consumption Coefficients for Houston (Climate Zone 3)

Building Type	Packaged and Split DX			
	Air Conditioner		Heat Pump	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
Apartment-Midrise	0.98	1,797	0.98	2,041
Clinic- Out Patient	0.82	3,116	0.82	3,283
College	0.85	2,175	--	--
Convenience	0.88	4,168	--	--
Grocery	0.87	2,935	--	--
Hospital	0.94	4,676	0.94	5,915
Hotel-Large	0.95	3,327	0.95	4,093
Hotel-Small	0.81	2,537	0.81	2,999
Motel	0.84	2,404	--	--
Nursing Home	0.84	2,368	--	--
Office-Large	0.88	1,903	0.88	2,184
Office-Medium	0.75	1,357	0.75	1,644
Office-Small	0.85	1,445	0.85	1,519
Public Assembly	0.86	2,559	--	--
Restaurant-Full Service	0.86	1,881	0.86	2,472
Restaurant-Quick Serve	0.85	1,536	0.85	1,852
Religious Worship	0.87	2,028	--	--
Retail-Single	0.91	1,437	0.91	1,637
School-Primary	0.84	1,265	0.84	1,544
School-Secondary	0.96	1,396	0.96	1,589
Service	0.87	2,429	--	--
Strip Mall	0.93	1,456	0.93	1,638
Supermarket	0.73	1,325	0.73	1,709
Warehouse	0.81	545	0.81	1,068

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-15: Demand and Energy Consumption Coefficients for Brownsville (Climate Zone 4)

Building Type	Packaged and Split DX			
	Air Conditioner		Heat Pump	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
Apartment-Midrise	0.94	2,381	0.94	2,555
Clinic-Out Patient	0.84	3,294	0.84	4,725
College	0.83	2,547	--	--
Convenience	0.85	4,647	--	--
Grocery	0.85	3,489	--	--
Hospital	0.92	5,286	0.92	6,366
Hotel-Large	0.95	4,041	0.95	4,751
Hotel-Small	0.78	3,019	0.78	3,388
Motel	0.84	2,973	--	--
Nursing Home	0.85	2,953	--	--
Office-Large	0.89	2,338	0.89	2,544
Office-Medium	0.79	1,545	0.79	1,760
Office-Small	0.82	1,782	0.82	1,843
Public Assembly	0.85	3,077	--	--
Restaurant-Full Service	0.84	2,187	0.84	2,709
Restaurant-Quick Serve	0.84	1,860	0.84	2,122
Religious Worship	0.84	2,181	--	--
Retail-Single	0.82	1,763	0.82	1,922
School-Primary	0.99	1,738	0.99	2,031
School-Secondary	0.96	1,704	0.96	1,869
Service	0.85	2,684	--	--
Strip Mall	0.85	1,757	0.85	1,908
Supermarket	0.84	1,772	0.84	2,140
Warehouse	0.78	687	0.78	1,111

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-16: Demand and Energy Consumption Coefficients for El Paso (Climate Zone 5)

Building Type	Mapped Building Type (for other Climate Zones)	Packaged and Split DX	
		Demand Coefficients	Energy Coefficients
Small Office	Office – Small	0.87	1,787
Office – Medium	Office – Medium	N/A	
Large Office	Office – Large	1.16	2,316
School	School – Primary	0.95	1,572
School	School – Secondary	0.95	1,572
College	College	0.99	1,804
Clinic – Out Patient	Clinic – Out Patient	N/A	
Hospital	Hospital	N/A	
Retail	Retail – Single	0.95	1,830
Strip Mall	Strip Mall	N/A	
Grocery	Supermarket	1.07	2,079
Fast Food	Restaurant – Quick Service	0.99	2,771
Restaurant	Restaurant – Full Service	0.90	2,105
Apartment – Midrise	Apartment – Midrise	N/A	
Motel	Hotel – Small	1.07	1,691
Hotel	Hotel – Large	0.79	1,825
Warehouse	Warehouse	0.85	1,985
Public Assembly	Public Assembly	0.93	1,731

Note: The building types for the El Paso climate zone are different than those used for other Climate Zones as they were developed using a different model, under a separate petition (41070). These have been mapped to the building types from Table 2-12 through Table 2-16 where possible.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL and RULs for this HVAC equipment are provided below. The reader should refer to the definitions of effective useful life and remaining useful life in the glossary in Volume 1 for guidance on how to determine the decision type for system installations.

Effective Useful Life (EUL)

The EUL for Split and Packaged Air Conditioners and Heat Pumps is 15 years.[29]

Remaining Useful Life (RUL)

The RUL of replaced systems is provided according to system age in Table 2-17. Both the RUL and EUL are needed to estimate savings for early retirement projects for two distinct periods: The ER period (RUL) and the ROB period (EUL - RUL). The calculations for early retirement projects are extensive, and as such are provided in Appendix D.

Table 2-17: Remaining Useful Life of Replaced Systems (Early Retirement)[30]

Age in Years of Replaced System	Split and Packaged A/C and HP Systems [years]	Age in Years of Replaced System	Split and Packaged A/C and HP Systems [years]
5	10	15	2.8
6	9.1	16	2.5
7	8.2	17	2.2
8	7.3	18	1.9
9	6.5	19	1.7
10	5.7	20	1.5
11	5.0	21	1.3
12	4.4	22	1.1
13	3.8	23	1.0
14	3.3	Unknown Age[31]	2.2

Additional Calculators and Tools

Oncor Calculator: Cooling Equipment Inventory – Metered M&V Method. This calculator provides a method to calculate savings for all HVAC measures which lie outside of the scope of the deemed savings methodology. For installations within the scope of the deemed savings methodology, Frontier's ACE tool is used.

[29] The EUL of 15 years has been cited in several places - PUCT Docket No. 36779, DOE 77 FR 28928, 10 CFR Part 431, and in the DEER 2014 update.

[30] PUCT Docket No. 40083, Attachment A describes the process in which the RUL of replaced systems has been calculated.

[31] As noted in Docket 40885, page 14-15: Failure probability weights are established by assuming that systems for which age information will be unavailable are likely to be older, setting a minimum age threshold, and using the survival functions for the relevant system type to estimate the likelihood that an operational system is of a given age beyond that threshold. Baseline efficiency for each year of system age is established relative to program year. Baseline efficiency levels can be estimated for the next ten program years, taking into account increments in efficiency standards that took place in the historical period.

Frontier A/C Evaluator (ACE) Calculator: This tool provides a deemed method to calculate energy and demand savings.

Program Tracking Data & Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/Action Type
- Building Type
- Climate Zone
- Baseline Equipment Rated Capacity
- Baseline Number of Units
- Baseline Equipment Type
- Baseline Age of System
- Post-Retrofit Equipment Rated Capacity
- Post-Retrofit Number of Units
- Post-Retrofit Efficiency Rating
- Post-Retrofit Make & Model
- Post-Retrofit Equipment Type

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Provides EUL for HVAC equipment.
- PUCT Docket 40083– Provides incorporation of Early Retirement savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and New Construction projects involving package and split systems.
- PUCT Docket 40885 – Provides a petition to revise deemed savings values for Commercial HVAC replacement measures. Items covered by this petition include the following:
- Updated baseline efficiencies use for estimating deemed savings for commercial PTAC/PTHP's, Room Air Conditioners and chilled water systems.
- Approved estimates of RUL of working chilled water systems.
- Updated demand and energy coefficients for all commercial HVAC systems.

- Updated EUL of centrifugal chilled water systems installed in ROB or New Construction projects.
- Provide a method for utilizing the early retirement concept developed in the petition in Docket No. 40083 for Packaged and Split DX systems and applied to chilled water systems when the age of the system being replaced cannot be ascertained.
- PUCT Docket 41070 – Provides energy and demand savings coefficients for an additional climate zone, El Paso, TX. Prior to this filing, savings for the Dallas-Fort Worth area were used for El Paso, but Dallas-Fort Worth has a colder winter, somewhat more moderate summer, more sunshine, and less precipitation than El Paso.
- PUCT Docket 43681 – Updated the approach for calculating early replacement energy and demand savings using a Net Present Value (NPV) method. Documented in Appendix D.

Relevant Standards and Reference Sources

- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1A through Table 6.8.1D.
- Code of Federal Regulations. Title 10. Part 431 – Energy Efficiency Program for Certain Commercial and Industrial Equipment. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/77

Document Revision History

Table 2-18: Nonresidential HVAC Single-Zone AC-HP History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Modified Early Retirement savings calculations and added references to Appendix D which details those calculations. Added heat pump minimum required heating efficiencies for reference. Revised baseline efficiency standards based on updates to federal standards.
v2.1	01/30/2015	Minor text updates and clarification of early retirement requirements.

2.2.2 HVAC Chillers Measure Overview

TRM Measure ID: NR-HV-CH

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 2-28 through Table 2-32

Fuels Affected: Electricity

Decision/Action Type: Replace on Burnout (ROB), Early Retirement (ER), and New Construction (NC)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Calculator

Measure Description

This document presents the deemed savings methodology for the installation of Chillers. This document covers assumptions made for baseline equipment efficiencies for early retirement (ER) based on the age of the replaced equipment, and replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards. It also provides estimates of baseline equipment efficiencies in the event that the actual age of the unit is unknown.

Applicable efficient measure types include[32]:

- Chillers (air-cooled centrifugal, water-cooled centrifugal, or air-cooled screw)
- Compressors (centrifugal, screw, or reciprocating)

Eligibility Criteria

For a measure to be eligible for this deemed savings approach the following conditions must be met:

- The existing and proposed cooling equipment are electric.
- The climate zone is determined from the county-to-climate-zone mapping table.

Coefficients are listed in Table 2-28 through Table 2-32 for the type of building and climate zone in which the retrofit occurs and the type of equipment involved. The building type must fall into

[32] Savings can also be claimed by a retrofit involving a change in equipment type (i.e. Air cooled packaged DX system to a water-cooled centrifugal chiller, or a split system air cooled heat pump to an air-cooled non-centrifugal chiller). In the event that this type of retrofit is performed, the tables from the following HVAC measure templates will need to be referenced:

- HVAC – Chillers
- Split System/Single Packaged Heat Pumps and Air Conditioners

one of the categories listed in Table 2-28 through Table 2-32. In the event that one of these conditions are not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Baseline Condition

Early Retirement

Early retirement projects involve the replacement of a working system. The early retirement baseline cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. Baseline efficiency is estimated according to the capacity, chiller type, and year of manufacture of the replaced system. When the chiller age can be determined (from a nameplate, building prints, equipment inventory list, etc.), the baseline efficiency levels provided in Table 2-19 through Table 2-22 should be used. When the system age is unknown, Table 2-23 through Table 2-26 should be used. Note that tables Table 2-23 through Table 2-26 provide failure probability-weighted average efficiency levels by equipment type and *program year*.[33]

Table 2-19: Early Retirement: Baseline Efficiency of Centrifugal Air-cooled Chillers when System Age is Known

Year Installed (Replaced System)	< 75 tons [EER]	≥ 75 to 150 tons [EER]	≥ 150 to 300 tons [EER]	≥ 300 tons [EER]	≥ 600 tons [EER]
≤ 2001[34]	9.210	9.210	8.529	8.529	8.529
2002 - 2010	9.554	9.554	9.554	9.554	9.554

Note: Intent of filing is that this is updated every few years so that systems greater than 5 years old will be eligible for early retirement.

[33] As noted in Docket 40885, page 14-15: Failure probability weights are established by assuming that systems for which age information will be unavailable are likely to be older, setting a minimum age threshold, and using the survival functions for the relevant system type to estimate the likelihood that an operational system is of a given age beyond that threshold. Baseline efficiency for each year of system age is established relative to program year. Baseline efficiency levels can be estimated for the next ten program years, taking into account increments in efficiency standards that took place in the historical period.

[34] PUCT Docket 40885 provides baseline efficiencies for chillers replaced via early retirement programs, as shown in Table 2-19 through Table 2-22. These baseline efficiencies are only created for systems between 1990 and 2012, yet common practice in Texas is to allow systems older than 1990 to use the same baseline efficiencies as those listed for 1990-2001.

Table 2-20: Early Retirement: Baseline Efficiency of Screw\Scroll\Recip. Air-Cooled Chillers when System Age is Known

Year Installed (Replaced System)	< 75 tons [EER]	≥ 75 to 150 tons [EER]	≥ 150 to 300 tons [EER]	≥ 300 tons [EER]	≥ 600 tons [EER]
≤ 2001[34]	9.210	9.210	8.529	8.529	8.529
2002 - 2010	9.554	9.554	9.554	9.554	9.554

Note: Intent of filing is that this is updated every few years so that systems greater than 5 years old will be eligible for early retirement.

Table 2-21: Early Retirement: Baseline Efficiency of Centrifugal Water-Cooled Chillers when System Age is Known

Year Installed (Replaced System)	< 75 tons [kW/ton]	≥ 75 to 150 tons [kW/ton]	≥ 150 to 300 tons [kW/ton]	≥ 300 tons [kW/ton]	≥ 600 tons [kW/ton]
≤ 2001[34]	0.926	0.926	0.837	0.748	0.748
2002 - 2010	0.703	0.703	0.634	0.577	0.577

Note: Intent of filing is that this is updated every few years so that systems greater than 5 years old will be eligible for early retirement.

Table 2-22: Early Retirement: Baseline Efficiency of Screw\Scroll\Recip. Water-Cooled Chillers when System Age is Known

Year Installed (Replaced System)	< 75 tons [kW/ton]	≥ 75 to 150 tons [kW/ton]	≥ 150 to 300 tons [kW/ton]	≥ 300 tons [kW/ton]	≥ 600 tons [kW/ton]
≤ 2001[34]	0.926	0.926	0.837	0.748	0.748
2002 - 2010	0.790	0.790	0.718	0.639	0.639

Note: Intent of filing is that this is updated every few years so that systems greater than 5 years old will be eligible for early retirement.

Table 2-23: Early Retirement: Baseline Efficiency [EER] of Screw\Scroll\Recip. Air-Cooled Chillers Undetermined Age

Size [tons]	2014	2015	2016	2017	2018	2019	2020	2021	2022
< 150	9.2	9.2	9.2	9.2	9.2	9.2	9.3	9.3	9.4
≥ 150 to < 300	8.5	8.5	8.5	8.5	8.6	8.7	8.8	8.9	9.0
≥ 300	8.5	8.5	8.5	8.5	8.6	8.7	8.8	8.9	9.0

Table 2-24: Early Retirement: Baseline Efficiency [EER] of Centrifugal Air-Cooled Chillers of Undetermined Age

Size [tons]	2014	2015	2016	2017	2018	2019	2020	2021	2022
< 150	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
≥ 150 to < 300	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.6
≥ 300	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.6

Table 2-25: Early Retirement: Baseline Efficiency [kW/ton] of Screw\Scroll\Recip. Water-Cooled Chillers of Undetermined Age

Size [tons]	2014	2015	2016	2017	2018	2019	2020	2021	2022
< 75	0.926	0.926	0.926	0.926	0.908	0.888	0.868	0.846	0.825
≥ 75 to < 150	0.837	0.837	0.837	0.837	0.821	0.803	0.784	0.764	0.745
≥ 150 to < 300	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.822
≥ 300 to < 600	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.736
≥600	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.736

Table 2-26: Early Retirement: Baseline Efficiency [kW/ton] of Water-Cooled Centrifugal Chillers of Undetermined Age

Size [tons]	2014	2015	2016	2017	2018	2019	2020	2021	2022
< 75	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.910
≥ 75 to < 150	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.926	0.910
≥ 150 to < 300	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.822
≥ 300 to < 600	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.736
≥600	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.736

Replace-on-Burnout (ROB) and New Construction (NC)

New baseline efficiency levels for chillers are provided in Table 2-27, which includes both full load and Integrated Part Load Value (IPLV) ratings. The IPLV accounts for chiller efficiency at part-load operation for a given duty cycle. These baseline efficiency levels reference standard ASHRAE 90.1-2010. This standard contains two paths for compliance, Path A or Path B, however Path A is the method chosen for consistency with the full-load efficiency conditions used in the savings algorithms.[35]

[35] According to ASHRAE 90.1-2007 Addenda M, Path A is intended for applications where significant operating time is expected at full-load conditions, while Path B is an alternative set of efficiency levels for water-cooled chillers intended for applications where significant time is spent at part-load operation (such as with a VSD chiller).

Table 2-27: Baseline Efficiencies for ROB and NC Water-Cooled and Air-Cooled Chillers[36]

System Type [Efficiency Units]		Capacity [Tons]	Path A	
			Full-Load	IPLV
Air-Cooled Chiller [EER]		< 150 tons	≥ 9.562	≥ 12.750
		≥ 150 tons	≥ 9.562	≥ 12.750
Water-Cooled Chiller [kW/ton]	Electrically-Operated, Positive Displacement (Screw/Scroll/ Reciprocating)	<75 tons	≤ 0.780	≤ 0.630
		≥ 75 tons and < 150 tons	≤ 0.775	≤ 0.615
		≥ 150 tons and < 300 tons	≤ 0.680	≤0.580
		≥ 300 tons	≤ 0.620	≤0.540
	Electrically-Operated, Centrifugal	< 300 tons	≤ 0.634	≤ 0.596
		≥ 300 tons and < 600 tons	≤ 0.576	≤ 0.549
		≥ 600 tons	≤ 0.570	≤ 0.539

High-Efficiency Condition

Chillers must exceed the minimum efficiencies specified in Table 2-27. Additional conditions for replace-on-burnout, early retirement and new construction are as follows:

New Construction and Replace on Burnout

The scope of the project for which incentives can be requested is limited to individual chillers (e.g. two 500 ton chillers and not the entire building HVAC systems).

Early Retirement

The high-efficiency retrofits must meet the following criteria[37]:

- Must be within 80% to 120% of the replaced electric cooling capacity
- No additional measures are being installed that directly affect the operation of the cooling equipment (i.e., control sequences, cooling towers, and condensers).

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$\boldsymbol{Peak\ Demand\ Savings}\ (\boldsymbol{kW}) = \boldsymbol{Tons} \times \left(\boldsymbol{a} \times \boldsymbol{\eta_{baseline}} - \boldsymbol{b} \times \boldsymbol{\eta_{retrofit}}\right)$$

Equation 11

[36] For ASHRAE 90.1-2010, a 2013 Supplement Addenda ch was filed which is effective January 1st, 2015. This Addenda contains revised full-load and part-load baseline efficiency standards for both Path A and Path B chillers, but the revisions are not reflected in these tables.
[37] From PUCT Docket #41070.

$$\boldsymbol{Energy\ Savings\ (kWh) = Tons \times (c \times \eta_{baseline} - d \times \eta_{retrofit})}$$

Equation 12

Where:

Tons	=	*Rated equipment cooling capacity at AHRI standard conditions (of the smallest unit to be installed or removed)*
$\eta_{baseline}$	=	*Efficiency of existing equipment (ER) or standard equipment (ROB/NC) (kW/Ton)*
$\eta_{retrofit}$	=	*Rated efficiency of the newly installed equipment (kW/Ton) - (Must exceed ASHRAE 90.1-2010, shown in Table 2-27)*
a,b	=	*Demand coefficients for appropriate climate zone, building type, and new and standard equipment types, see Table 2-28 through Table 2-32*
c,d	=	*Energy coefficients for appropriate climate zone, building type, and new and standard equipment types, see Table 2-28 through Table 2-32 (hours)*

Air- to Water-Cooled Replacement: Adjustments for Auxiliary Equipment[38]:

The equipment efficiency for an air-cooled chiller includes condenser fans, but the equipment efficiency for a water-cooled chiller does not include the condenser water pump and cooling tower. Therefore, the savings must be reduced, in the event that an air-cooled chiller is replaced with a water-cooled chiller, to account for the peak demand and energy consumption of the water-cooled system's additional equipment. This type of retrofit is possible in ROB and ER situations. The following equations are used:

$$\boldsymbol{kW_{CW\ pump\ \&\ CT\ fan} = (HP_{CW\ pump} + HP_{CT\ fan}) \times \frac{0.746}{0.86} \times 0.80}$$

Equation 13

$$\boldsymbol{kWh_{CW\ pump\ \&\ CT\ fan} = kW_{CW\ pump\ \&\ CT\ fan} \times 8,760}$$

Equation 14

Where:

$HP_{CW\ pump}$	=	*Horsepower of the condenser water pump*
$HP_{CT\ fan}$	=	*Horsepower of the cooling tower fan*
0.746	=	*Conversion from HP to kW*

[38] This extra adjustment is noted in PUCT Docket No. 41070.

0.86 = *Assumed equipment efficiency*

0.80 = *Assumed load factor*

8,760 = *Annual run time hours*

The energy and demand of the condenser water pump and cooling tower fans are subtracted from the final savings, to reach the net savings:

$$kW_{savings,net} = kW - kW_{CW\ pump\ \&\ CT\ fan}$$

Equation 15

$$kWh_{savings,net} = kWh - kWh_{CW\ pump\ \&\ CT\ fan}$$

Equation 16

Table 2-21 through Table 2-27 provide efficiency ratings for baseline equipment and the efficiency ratings are given in terms of SEER, EER, COP or kW/ton. In the cases where the efficiency is not provided in terms of kW/ton, a conversion to kW/ton needs to be performed, using the following conversion calculations:

$$\frac{kW}{Ton} = \frac{12}{EER}$$

Equation 17

$$\frac{kW}{Ton} = \frac{3.516}{COP}$$

Equation 18

$$\frac{kW}{Ton} = \frac{12}{SEER \times 0.697 + 2.0394}$$

Equation 19

Early Retirement Savings

The first year savings algorithms in equations 13 and 14 are used for all HVAC projects, across NC, ROB, and ER projects. However, ER projects require a weighted savings calculated over both the early retirement period and the replace-on-burnout period, and take into account the EUL and the RUL. The final reported savings for ER projects are not actually a “first-year” savings, but an “average annual savings over the lifetime (EUL) of the measure”. These savings calculations are explained in Appendix D.

Table 2-28 through Table 2-32 present the demand and energy coefficients. These HVAC coefficients vary by climate zone, building type, and equipment type. A description of the calculation method can be found in Docket No. 40885, Attachment B.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Deemed Energy and Demand Savings Tables

Deemed energy and demand savings coefficients have been calculators by building type and climate zone for chillers in Table 2-28 through Table 2-32. In some cases, a coefficient may not have been developed for a certain technology, climate zone, and building type combination. In the even that a coefficient has not been created, the specific combination is not allowed as a valid option.

Table 2-28: Demand and Energy Consumption Coefficients for Amarillo (Climate Zone 1)

Building Type	Chiller			
	Air Cooled		Water Cooled	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
College	0.87	1,115	0.68	1,243
Grocery	--	--	0.67	1,892
Hospital	0.86	2,873	0.74	3,545
Hotel – Large	0.77	1,965	0.72	2,396
Nursing Home	0.87	1,230	0.65	1,260
Office – Large	0.92	1,710	0.82	2,104
Public Assembly	0.87	1,404	0.65	1,444
Religious Worship	0.82	848	0.67	856
School - Secondary	0.82	1,028	0.75	1,244

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-29: Demand and Energy Consumption Coefficients for Fort Worth (Climate Zone 2)

Building Type	Chiller			
	Air Cooled		Water Cooled	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
College	0.89	1,587	0.81	1,761
Grocery	--	--	0.87	2,708
Hospital	0.96	3,574	0.83	4,323
Hotel – Large	0.82	2,596	0.80	3,159
Nursing Home	0.90	1,744	0.82	1,854
Office – Large	0.92	1,710	0.82	2,104
Public Assembly	0.90	2,005	0.84	2,116
Religious Worship	0.88	1,355	0.83	1,396
School - Secondary	0.88	1,333	0.84	1,669

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-30: Demand and Energy Consumption Coefficients for Houston (Climate Zone 3)

Building Type	Chiller			
	Air Cooled		Water Cooled	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
College	0.80	1,858	0.84	2,099
Grocery	--	--	0.88	3,012
Hospital	0.82	3,753	0.81	4,708
Hotel – Large	0.76	2,690	0.82	3,475
Nursing Home	0.80	1,960	0.84	2,172
Office – Large	0.79	1,680	0.82	2,185
Public Assembly	0.81	2,264	0.86	2,482
Religious Worship	0.83	1,474	0.84	1,594
School - Secondary	0.78	1,297	0.82	1,726

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-31: Demand and Energy Consumption Coefficients for Brownsville (Climate Zone 4)

Building Type	Chiller			
	Air Cooled		Water Cooled	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
College	0.80	2,340	0.87	2,583
Grocery	--	--	0.85	3,603
Hospital	0.85	4,208	0.80	5,160
Hotel – Large	0.90	3,575	0.82	3,969
Nursing Home	0.80	2,634	0.85	2,890
Office – Large	0.85	2,018	0.83	2,562
Public Assembly	0.80	2,857	0.85	3,085
Religious Worship	0.81	1,754	0.85	1,907
School - Secondary	0.81	1,614	0.85	2,094

Note: These values have come from both Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types that were originally available in Docket 30331 were updated in Docket 40885. For those building types that did not have updated coefficients, their values remained in use from Docket 30331.

Table 2-32: Demand and Energy Consumption Coefficients for El Paso (Climate Zone 5)

Building Type	Mapped Building Type (to other Climate Zones)	Chiller			
		Air Cooled		Water Cooled	
		Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
Small Office	Office – Small	0.88	1,614	0.99	1,873
Large Office	Office – Large	1.05	2,134	1.01	2,213
School	School – Primary	0.87	979	0.93	1,141
School	School – Secondary	0.87	979	0.93	1,141
College	College	0.93	1,278	0.96	1,458
Hospital	Hospital	0.97	2,225	0.98	2,705
Retail	Retail – Single	0.86	1,553	0.77	1,781
Grocery	Grocery / Supermarket	--		0.83	2,468
Hotel	Hotel – Large	0.78	1,844	0.70	1,996
Warehouse	Warehouse	0.80	1,161	0.82	1,381
Public Assembly	Public Assembly	0.77	1,724	0.74	2,013

Note: The building types for El Paso climate zone are different than those used for other Climate Zones. These have been mapped to the building types from Table 2-28 through Table 2-31 where possible.

Measure Life and Lifetime Savings

Effective Useful Life (EUL)

The EUL of HVAC equipment is provided below:

- Screw / Scroll / Reciprocating Chillers – 20 years[39]
- Centrifugal Chillers – 25 years[40]

Remaining Useful Life (RUL)

The RUL of replaced systems is provided according to system age in Table 2-17. Both the RUL and EUL are needed to estimate savings for early retirement projects for two distinct periods: The ER period (RUL) and the ROB period (EUL - RUL). The calculations for early retirement projects are extensive, and as such are provided in Appendix D.

[39] PUCT Docket No. 36779. The original source was DEER 2008, but DEER 2014 provides the same value of 20 years for "High Efficiency Chillers". DEER does not differentiate between centrifugal and non-centrifugal chillers.

[40] PUCT Docket No. 40885, review of multiple studies looking at the lifetime of Centrifugal Chillers as detailed in petition workpapers.

Table 2-33: Remaining Useful Life of Replaced Systems (Early Retirement)[41]

Age in Years of Replaced System	Non-Centrifugal Chilled Water Systems	Centrifugal Chilled Water Systems	Age in Years of Replaced System	Non-Centrifugal Chilled Water Systems	Centrifugal Chilled Water Systems
5	14.7	19.9	22	2.9	6.3
6	13.7	18.9	23	2.6	5.9
7	12.7	17.9	24	2.4	5.6
8	11.8	16.9	25	2.1	5.4
9	10.9	15.9	26	1.9	5.1
10	10.0	14.9	27	1.8	4.9
11	9.1	13.9	28	1.6	4.7
12	8.3	12.9	29	1.5	4.5[42]
13	7.5	11.9	30	1.3	4.3
14	6.8	10.9	31	1.2	4.1
15	6.2	10.1	32	N/A	4
16	5.5	9.3	33	N/A	3.8
17	5.0	8.7	34	N/A	3.7
18	4.5	8.1	35	N/A	3.6
19	4.0	7.5	36	N/A	3.5
20	3.6	7.1	Unknown Age[43]	3.2	5.1
21	3.2	6.6			

[41] PUCT Docket No. 40085, Attachment A describes the process in which the RUL of replaced systems has been calculated.

[42] The correct value is listed in this table, and differs from Table 5 of PUC Petition 40885 due to a typographical error in the petition.

[43] As noted in Docket 40885, page 14-15: Failure probability weights are established by assuming that systems for which age information will be unavailable are likely to be older, setting a minimum age threshold, and using the survival functions for the relevant system type to estimate the likelihood that an operational system is of a given age beyond that threshold. Baseline efficiency for each year of system age is established relative to program year. Baseline efficiency levels can be estimated for the next ten program years, taking into account increments in efficiency standards that took place in the historical period.

Additional Calculators and Tools

Oncor Calculator: Cooling Equipment Inventory – Metered M&V Method. This calculator provides a method to calculate savings for all HVAC measures which lie outside of the scope of the deemed savings methodology. For installations within the scope of the deemed savings methodology, Frontier's ACE tool is used.

Frontier A/C Evaluator (ACE) Calculator: This tool provides a deemed method to calculated energy and demand savings.

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/Action Type
- Building Type
- Climate Zone
- Baseline Equipment Rated Capacity
- Baseline Number of Units
- Baseline Efficiency Rating
- Baseline Make & Model
- Baseline Equipment Type
- Baseline Age of System
- Post-Retrofit Equipment Rated Capacity
- Post-Retrofit Number of Units
- Post-Retrofit Efficiency Rating
- Post-Retrofit Make & Model
- Post-Retrofit Equipment Type

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Provides EUL for HVAC equipment.
- PUCT Docket 40083– Provides incorporation of Early Retirement savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and New Construction projects involving package and split systems.

- PUCT Docket 40885 – Provides a petition to revise deemed savings values for Commercial HVAC replacement measures. Items covered by this petition include the following:
- Updated baseline efficiencies use for estimating deemed savings for commercial PTAC/PTHP's, Room Air Conditioners and chilled water systems.
- Approved estimates of RUL of working chilled water systems.
- Updated demand and energy coefficients for all commercial HVAC systems.
- Updated EUL of centrifugal chilled water systems installed in ROB or New Construction projects.
- Provide a method for utilizing the early retirement concept developed in the petition in Docket No. 40083 for Packaged and Split DX systems and applied to chilled water systems when the age of the system being replaced cannot be ascertained.
- PUCT Docket 41070 – Provides energy and demand savings coefficients for an additional climate zone, El Paso, TX. Previously these savings were taken from the Dallas-Fort Worth area, which has a colder winter, somewhat more moderate summer, more sunshine, and less precipitation than El Paso.
- PUCT Docket 43681 – Updated the approach for calculating early replacement energy and demand savings using a Net Present Value (NPV) method. Documented in Appendix D.

Relevant Standards and Reference Sources

- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings except Low-Rise Residential Buildings. Table 6.8.1A through Table 6.8.1D.

Document Revision History

Table 2-34: Nonresidential HVAC-Chillers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Modified savings calculations surrounding Early Retirement programs, and revised details surrounding RUL and Measure Life. Added references to Appendix D for EUL and RUL discussion, and Net Present Value (NPV) equations.
v2.1	01/30/2015	Minor text updates and clarification of early retirement requirements.

2.2.3 Packaged Terminal Air Conditioners, Heat Pumps and Room Air Conditioners Measure Overview

TRM Measure ID: NR-HV-PT

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: Varies by equipment technology

Fuels Affected: Electricity

Decision/Action Type: Replace on Burnout (ROB) and New Construction (NC)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculations

Savings Methodology: Calculator

Measure Description

This section presents the deemed savings methodology for the installation of Packaged Terminal Air Conditioners (PTAC), Packaged Terminal Heat Pumps (PTHP), and Room AC (RAC) systems. This document covers assumptions made for baseline equipment efficiencies for replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards.

Applicable efficient measure types include:

- Packaged terminal air conditioners and heat pumps
- Room air conditioners

Eligibility Criteria

For a measure to be eligible for this deemed savings approach the following conditions will be met:

- The existing and proposed cooling equipment are electric.
- The climate zone is determined from the county-to-climate-zone mapping table.
- For PTAC/PTHP equipment types, the eligible building types include only Hotel – Small and Hotel – Large[44].

[44] The original petition did not include the "Hotel – Large" business type. This application was added in TRMv2 as a short-term, conservative savings estimate, but more accurate savings estimates should be developed for a future TRM.

- For RAC units, the building types listed in the Split System/Single-Packaged Heat Pumps and Air Conditioners section, in Table 2-12 through Table 2-16, are eligible[45]. Additionally, only units meeting the criteria listed in Table 2-36 are eligible.

In the event that one of these conditions are not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Baseline Condition

Table 2-35 provides baseline efficiency standards for PTAC and PTHP units and have been updated, reflecting the new federal standards for Packaged Terminal Air Conditioners and Heat Pumps put in place in February 2013 and reflected in 10 CFR 431.

Table 2-35: Baseline Efficiency Levels for PTAC/PTHP ROB and NC Units

Equipment	Category[46]	Cooling Capacity [Btuh]	Energy Conservation Standards (Cooling)	Energy Conservation Standards (Heating)
PTAC	Standard Size	<7,000	$EER = 11.7$	--
		7,000-15,000	$EER = 13.8 - \left(0.300 \times \frac{Cap}{1000}\right)$	--
		>15,000	$EER = 9.3$	--
	Non-Standard Size	<7,000	$EER = 9.4$	--
		7,000-15,000	$EER = 10.9 - \left(0.213 \times \frac{Cap}{1000}\right)$	--
		>15,000	$EER = 7.7$	--
PTHP	Standard Size	<7,000	$EER = 11.9$	$COP = 3.3$
		7,000-15,000	$EER = 14.0 - \left(0.300 \times \frac{Cap}{1000}\right)$	$COP = 3.7 - \left(0.052 \times \frac{Cap}{1000}\right)$
		>15,000	$EER = 9.5$	$COP = 2.9$
	Non-Standard Size	<7,000	$EER = 9.3$	$COP = 2.7$
		7,000-15,000	$EER = 10.8 - \left(0.213 \times \frac{Cap}{1000}\right)$	$COP = 2.9 - \left(0.026 \times \frac{Cap}{1000}\right)$
		>15,000	$EER = 7.6$	$COP = 2.5$

[45] The values for DX systems have been used. PUCT Docket 40885 does not specify the energy and demand coefficients to use for RAC units, and the so the utilities have previously used the DX values, as they cover a larger range of building types than the PTAC/PTHP coefficients. However, the PTAC/PTHP coefficients are likely to be a more realistic energy and demand factor than those for DX systems.

[46] Standard Size refers to equipment with wall sleeve dimensions having an external wall opening greater 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 in^2.
Non-Standard Size refers to 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 in^2.

Table 2-36 reflects the standards for Room Air Conditioners, specified in 10 CFR 430.32(b).

Table 2-36: Baseline Efficiency Levels for Room Air Conditioners ROB and NC Units[47]

Category	Capacity [Btuh]	Baseline Efficiency [EER]
Without reverse cycle, with louvered sides	< 8,000	11.0
	≥ 8,000 and < 14,000	10.9
	≥ 14,000 and < 20,000	10.7
	≥ 20,000 and < 25,000	9.4
	≥ 25,000	9.0
Without reverse cycle, without louvered sides	< 8,000	10.0
	≥ 8,000 and < 11,000	9.6
	≥ 11,000 and < 14,000	9.5
	≥ 14,000 and < 20,000	9.3
	≥ 20,000	9.4
With reverse cycle, with louvered sides	< 20,000	9.8
	≥ 20,000	9.3
With reverse cycle, without louvered sides	< 14,000	9.3
	≥ 14,000	8.7
Casement-only	All capacities	9.5
Casement-slider	All capacities	10.4

High-Efficiency Condition

The high-efficiency retrofits must meet exceed the minimum federal standards found in Table 2-35 and Table 2-36.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$\boldsymbol{Peak\ Demand\ Savings\ (kW) = Tons \times \left(a \times \eta_{baseline} - b \times \eta_{retrofit}\right)}$$

Equation 20

[47] Direct final rule for new Room Air conditioner Standards was published on April 21st, 2011 (76 FR 22454), effective August 19th, 2011, and are required starting June 1st, 2014. These are found in 10 CFR Part 430.

$$\boldsymbol{Energy\ Savings\ (kWh) = Tons \times \left(c \times \eta_{baseline} - d \times \eta_{retrofit}\right)}$$

Equation 21

Where:

Tons	=	*Rated equipment cooling capacity at AHRI standard conditions (of the smallest unit to be installed or removed)*
$\eta_{baseline}$	=	*Efficiency of standard equipment (kW/Ton)*
$\eta_{retrofit}$	=	*Rated efficiency of the newly installed equipment (kW/Ton) - (Must exceed minimum federal standards found in Table 2-35 and Table 2-36)*
a,b	=	*Demand coefficients for appropriate climate zone, building type, and new and standard equipment types, see Table 2-37.*
c,d	=	*Energy coefficients for appropriate climate zone, building type, and new and standard equipment types, see Table 2-37* (hours).

Table 2-35 and Table 2-36 provide efficiency ratings for baseline equipment. As the efficiency is provided in terms of EER, a conversion has been provided below to convert to kW/ton, which is required for the algorithms.

$$\boldsymbol{\frac{kW}{Ton} = \frac{12}{EER}}$$

Equation 22

Table 2-37 shows the demand and energy coefficients. These HVAC coefficients are calculated in Docket No. 40885, by climate zone, building type, and equipment type. A description of the calculation method can also be found in Docket No. 40885, Attachment B.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Deemed Energy and Demand Savings Tables

Table 2-37: PTAC/PTHP Equipment: Demand and Energy Consumption Coefficients by Climate Zone for Hotel – Small and Hotel – Large Building Types[48]

Climate Zone	Packaged Terminal Unit			
	Air Conditioner		Heat Pump	
	Demand Coefficients	Energy Coefficients	Demand Coefficients	Energy Coefficients
Amarillo (Climate Zone 1)	0.51	1,359	0.51	1,720
Fort Worth (Climate Zone 2)	0.61	1,834	0.61	2,042
Houston (Climate Zone 3)	0.55	1,992	0.55	2,035
Brownsville (Climate Zone 4)	0.49	2,223	0.49	2,273
El Paso (Climate Zone 5)[49]	0.61	1,834	0.61	2,042

Table 2-38: RAC Equipment: Demand and Energy Consumption Coefficients[50]

For Room AC units, use the energy and demand coefficients for the Split System/Single Packaged Heat Pumps and Air Conditioners Measure that are presented in Table 2-12 through Table 2-16.

Measure Life and Lifetime Savings

The EUL of 15 years for unitary/split Air Conditioners / Heat Pumps is considered to encompass PTAC/PTHP units, as an EUL is not explicitly specified for these. The EUL of Room AC units has been updated to 11 years based on recent updates the Department of Energy (DOE) has made to its Residential Room Air Conditioner measure.[51]

48 Docket No. 40885 provides demand and energy savings by building type and cooling equipment for the four different climate zones. This original petition was dated 10/29/2012. An amended petition, dated 11/13/2012 was approved, which provides the original energy and demand coefficients (Table 2-12 through Table 2-16, but also amended Tables (B3a through B3d and B4a through B4d)

49 No values have been published for this measure for El Paso, Climate Zone 5, but per a comment received from Frontier, Climate Zone 5 uses the Fort Worth (Climate Zone 2) weather values.

50 The values for DX systems have been historically used for RAC units because PUCT Docket 40885 did not explicitly specify the energy and demand coefficients for RAC units. However, an RAC is more like a PTAC/PTHP than a DX system, and RAC-specific coefficients should be developed in a future TRM.

51 The updates were made in Federal Register, 76 FR 22582-22584, but the reference to the EUL is found here: http://www.regulations.gov/contentStreamer?objectId=0900006480c34c55&disposition=attachment&contentType=pdf. Accessed 04/02/2014. This value is listed as 10.5 years, and has been rounded up to 11.

Additional Calculators and Tools.

Oncor Calculator: Cooling Equipment Inventory – Metered M&V Method. This calculator provides a method to calculate savings for all HVAC measures, which lie outside of the scope of the deemed savings methodology.

Frontier A/C Evaluator (ACE) Calculator: This tool provides a deemed method to calculate energy and demand savings.

Program Tracking Data & Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/Action Type
- Building Type
- Climate Zone
- Baseline Equipment Rated Capacity
- Baseline Number of Units
- Baseline Efficiency Rating
- Baseline Make & Model
- Baseline Equipment Type
- Baseline Age of System
- Post-Retrofit Equipment Rated Capacity
- Post-Retrofit Number of Units
- Post-Retrofit Efficiency Rating
- Post-Retrofit Make & Model
- Post-Retrofit Equipment Type
- PTAC/PTHP Size Category (Standard/Non-Standard) or Room AC Configuration Category

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Provides EUL for HVAC equipment.
- PUCT Docket 40083– Provides incorporation of Early Retirement savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and New Construction projects involving package and split systems.

- PUCT Docket 40885 – Provides a petition to revise deemed savings values for Commercial HVAC replacement measures. This petition updated demand and energy coefficients for all commercial HVAC systems.

Relevant Standards and Reference Sources

- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1A through Table 6.8.1D.
- Code of Federal Regulations. Title 10. Part 431 – Energy Efficiency Program for Certain Commercial and Industrial Equipment. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/45
- Code of Federal Regulations. Title 10. Part 430 – Energy Efficiency Program for Certain Commercial and Industrial Equipment. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/41

Document Revision History

Table 2-39: Nonresidential HVAC PTAC-PTHP/Room AC History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Updated EUL value for DX units, based on PUCT Docket No. 36779. Updated the minimum baseline efficiencies for Standard PTAC and PTHP based on new federal standards, 10 CFR 431.97, and updated the minimum efficiencies for Room AC units and added specifications for new Casement-only and Casement-slider equipment. Expanded application to "Hotel – Large" business type for PTAC/PTHP equipment, and changed the RAC energy and demand coefficients to reference those for DX systems, rather than those for PTAC/PTHP systems.
v2.1	01/30/2015	Corrections to energy and demand coefficients for heat pumps in Climate Zone 3 (Houston); Table 2-37.

2.2.4 HVAC Variable Frequency Drive (VFD) on Air Handler Unit (AHU) Supply Fans Measure Overview

TRM Measure ID: NR-HV-VF

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 2-40 though Table 2-42

Fuels Affected: Electricity

Decision/Action Type: Retrofit (RET)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Look-up Tables (fan type, motor hp, Climate Zone, Building Type)

<u>Measure Description</u>

This measure involves the installation of a VFD on an existing AHU supply fan to replace either outlet damper or inlet guide vane part-load control. The fan is in a variable air volume (VAV) system with terminal VAV boxes. This measure accounts for the interactive air-conditioning demand savings during the utility defined peak period. The savings are on a per-HP basis.

Eligibility Criteria

Supply fans may not have variable pitch. New construction and constant-volume systems are ineligible. Supply fans must be less than or equal to 100 HP.

Baseline Condition

The baseline is a centrifugal supply fan with a single-speed motor, a direct expansion (DX) air-conditioning (AC) unit, and VAV boxes. The motor is a standard efficiency motor based on ASHRAE Standard 90.1-2004 or other specific standards. The AC unit has standard cooling efficiency based on ASHRAE 90.1-2004. The part-load fan control is either an outlet damper, inlet damper or inlet guide vane.

High-Efficiency Condition

The high efficiency condition is an installation of a VFD on an AHU supply fan. The existing damper or inlet guide vane will be removed or set completely open permanently after installation. The VFD will maintain a constant static pressure by adjusting fan speed and delivery the same amount of air as the baseline condition.

Energy and Demand Savings Methodology

The energy and demand savings algorithms provided below are listed for reference purposes only. These savings have already been calculated and provided in deemed savings tables, shown below in Table 2-40 through Table 2-42.

Savings Algorithms and Input Variables

$$kW_{full} = 0.746 \times HP \times \frac{LF}{\eta}$$

Equation 23

$$kW_i = kW_{full} \times \%power$$

Equation 24

$$kWh = \sum_{i=1}^{8760} kW_i \times schedule_i$$

Equation 25

$$Annual\ Energy\ Savings\ [kWh] = kWh_{baseline} - kWh_{new}$$

Equation 26

$$\begin{aligned} Demand\ Savings\ [kW] \\ &= (CF_{baseline} \times kW_{baseline} - CF_{new} \times kW_{new}) \\ &+ \left((CF_{baseline} \times kW_{baseline} - CF_{new} \times kW_{new}) \times \frac{3.412}{Cooling_{SEER}} \right) \end{aligned}$$

Equation 27

Where:

HP	=	*Rated horsepower of the motor*
LF	=	*Load factor – ratio of the operating load to the nameplate rating of the motor*
η	=	*Motor efficiency – the motor is assumed a standard efficiency motor*
0.746	=	*HP to kW conversion factor*
%power	=	*Percentage of full load power calculated by an equation based on the control type (outlet damper, inlet box damper, inlet guide vane, VFD).*
$schedule_i$	=	*1 when building is occupied, 0.2 when building is unoccupied.*
$CF_{baseline}$	=	$\frac{Total_{kWh}}{kW_{baseline} \times 510}$ *during the utility defined peak period (510 hours total)*
$kW_{baseline}$	=	*Maximum baseline demand during the utility defined peak period*

CF_{new} = $\frac{Total_{kWh}}{kW_{new} \times 510}$ *during the utility defined peak period (510 hours total)*

kW_{new} = *Maximum post-installation demand during the utility defined peak period*

$Cooling_{SEER}$ = *Air conditioner cooling efficiency, assumed at 11.2*

Deemed Energy and Demand Savings Tables

Table 2-40: Deemed Energy and Demand Savings Values for Outlet Damper Part-Load Fan Control by Climate Zone

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
Hospital & HealthCare										
1	0.063	1,081	0.084	1,111	0.094	1,079	0.073	1,067	0.105	1,177
2	0.136	2,135	0.168	2,196	0.178	2,132	0.136	2,109	0.210	2,325
3	0.189	3,090	0.241	3,178	0.252	3,085	0.199	3,052	0.304	3,366
5	0.315	5,091	0.388	5,236	0.42	5,083	0.336	5,028	0.504	5,544
7.5	0.472	7,549	0.587	7,764	0.629	7,537	0.493	7,456	0.755	8,222
10	0.619	9,952	0.766	10,235	0.829	9,936	0.661	9,829	0.997	10,838
15	0.923	14,646	1.133	15,064	1.217	14,623	0.965	14,465	1.458	15,951
20	1.227	19,529	1.511	20,085	1.626	19,497	1.290	19,287	1.951	21,268
25	1.521	24,196	1.867	24,885	2.014	24,157	1.594	23,896	2.413	26,351
30	1.804	28,814	2.224	29,635	2.392	28,768	1.899	28,457	2.874	31,380
40	2.392	38,127	2.948	39,214	3.168	38,066	2.518	37,655	3.808	41,523
50	2.99	47,659	3.682	49,017	3.965	47,583	3.147	47,069	4.762	51,904
60	3.567	56,822	4.385	58,441	4.72	56,731	3.745	56,118	5.675	61,883
75	4.427	70,572	5.455	72,583	5.864	70,459	4.658	69,698	7.049	76,858
100	5.906	94,096	7.269	96,777	7.815	93,946	6.210	92,930	9.399	102,477
Office - Large										
1	0.063	516	0.084	531	0.094	515	0.073	510	0.105	571
2	0.136	1,019	0.168	1,049	0.178	1,018	0.136	1,008	0.210	1,129
3	0.189	1,475	0.241	1,519	0.252	1,474	0.199	1,458	0.304	1,634
5	0.315	2,430	0.388	2,502	0.42	2,428	0.336	2,402	0.504	2,692
7.5	0.472	3,603	0.587	3,711	0.629	3,600	0.493	3,562	0.755	3,991
10	0.619	4,749	0.766	4,892	0.829	4,745	0.661	4,696	0.997	5,262
15	0.923	6,990	1.133	7,199	1.217	6,984	0.965	6,911	1.458	7,744
20	1.227	9,320	1.511	9,599	1.626	9,312	1.290	9,215	1.951	10,325
25	1.521	11,547	1.867	11,893	2.014	11,537	1.594	11,418	2.413	12,793
30	1.804	13,751	2.224	14,163	2.392	13,739	1.899	13,597	2.874	15,234
40	2.392	18,195	2.948	18,741	3.168	18,180	2.518	17,992	3.808	20,159
50	2.990	22,744	3.682	23,426	3.965	22,725	3.147	22,490	4.762	25,198
60	3.567	27,117	4.385	27,930	4.72	27,094	3.745	26,814	5.675	30,043
75	4.427	33,679	5.455	34,689	5.864	33,651	4.658	33,302	7.049	37,313
100	5.906	44,905	7.269	46,252	7.815	44,868	6.210	44,403	9.399	49,751
Office - Small										
1	0.052	466	0.073	480	0.073	463	0.063	461	0.094	517
2	0.105	921	0.136	949	0.147	915	0.115	911	0.178	1,021
3	0.157	1,333	0.199	1,374	0.21	1,324	0.168	1,319	0.262	1,477
5	0.262	2,196	0.325	2,263	0.346	2,182	0.273	2,173	0.430	2,434
7.5	0.388	3,256	0.483	3,356	0.514	3,235	0.409	3,223	0.629	3,609
10	0.514	4,292	0.64	4,424	0.682	4,265	0.545	4,248	0.839	4,758
15	0.745	6,316	0.934	6,512	0.997	6,277	0.797	6,253	1.227	7,002
20	0.997	8,422	1.248	8,682	1.332	8,370	1.059	8,337	1.636	9,336
25	1.238	10,435	1.542	10,757	1.647	10,370	1.322	10,329	2.035	11,568
30	1.479	12,426	1.846	12,810	1.962	12,349	1.573	12,301	2.423	13,775

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
40	1.951	16,443	2.434	16,951	2.591	16,341	2.077	16,277	3.199	18,228
50	2.434	20,553	3.042	21,189	3.241	20,426	2.591	20,346	3.997	22,785
60	2.906	24,505	3.63	25,262	3.871	24,353	3.095	24,257	4.773	27,166
75	3.609	30,435	4.511	31,375	4.804	30,246	3.839	30,127	5.927	33,740
100	4.815	40,579	6.011	41,834	6.409	40,328	5.130	40,170	7.899	44,986
Education – K-12										
1	0.021	474	0.031	486	0.031	463	0.021	468	0.042	516
2	0.042	936	0.063	960	0.052	915	0.052	925	0.073	1,020
3	0.063	1,355	0.084	1,390	0.084	1,324	0.073	1,339	0.105	1,477
5	0.115	2,233	0.147	2,290	0.126	2,181	0.126	2,206	0.178	2,433
7.5	0.168	3,311	0.21	3,395	0.189	3,234	0.178	3,271	0.262	3,607
10	0.22	4,365	0.283	4,476	0.252	4,263	0.241	4,312	0.346	4,755
15	0.325	6,424	0.409	6,587	0.378	6,274	0.357	6,347	0.514	6,998
20	0.430	8,565	0.545	8,782	0.504	8,365	0.472	8,462	0.682	9,331
25	0.535	10,612	0.671	10,881	0.619	10,365	0.587	10,485	0.850	11,561
30	0.629	12,637	0.808	12,958	0.734	12,343	0.692	12,486	1.018	13,768
40	0.839	16,722	1.07	17,147	0.976	16,333	0.923	16,522	1.343	18,218
50	1.049	20,903	1.332	21,433	1.217	20,416	1.154	20,652	1.678	22,772
60	1.248	24,922	1.584	25,554	1.458	24,341	1.374	24,623	1.993	27,151
75	1.553	30,952	1.972	31,738	1.804	30,231	1.710	30,581	2.476	33,721
100	2.067	41,270	2.633	42,317	2.413	40,308	2.276	40,775	3.304	44,961
Education – College & University										
1	0.063	535	0.084	551	0.094	533	0.073	529	0.105	593
2	0.136	1,057	0.168	1,089	0.178	1,054	0.136	1,044	0.210	1,171
3	0.189	1,530	0.241	1,576	0.252	1,525	0.199	1,511	0.304	1,695
5	0.315	2,521	0.388	2,597	0.420	2,513	0.336	2,490	0.504	2,793
7.5	0.472	3,738	0.587	3,850	0.629	3,726	0.493	3,692	0.755	4,141
10	0.619	4,928	0.766	5,076	0.829	4,912	0.661	4,867	0.997	5,459
15	0.923	7,252	1.133	7,470	1.217	7,229	0.965	7,163	1.458	8,035
20	1.227	9,669	1.511	9,960	1.626	9,639	1.290	9,551	1.951	10,713
25	1.521	11,980	1.867	12,341	2.014	11,943	1.594	11,834	2.413	13,273
30	1.804	14,267	2.224	14,696	2.392	14,222	1.899	14,092	2.874	15,807
40	2.392	18,878	2.948	19,446	3.168	18,819	2.518	18,647	3.808	20,916
50	2.990	23,598	3.682	24,308	3.965	23,523	3.147	23,308	4.762	26,145
60	3.567	28,135	4.385	28,981	4.720	28,046	3.745	27,790	5.675	31,171
75	4.427	34,943	5.455	35,994	5.864	34,832	4.658	34,514	7.049	38,714
100	5.906	46,591	7.269	47,992	7.815	46,443	6.210	46,019	9.399	51,619
Retail										
1	0.063	645	0.084	664	0.094	646	0.073	634	0.105	716
2	0.136	1,275	0.168	1,311	0.178	1,277	0.136	1,253	0.21	1,415
3	0.189	1,845	0.241	1,898	0.252	1,848	0.199	1,813	0.304	2,047
5	0.315	3,040	0.388	3,127	0.42	3,044	0.336	2,987	0.504	3,373
7.5	0.472	4,507	0.587	4,637	0.629	4,514	0.493	4,430	0.755	5,002
10	0.619	5,942	0.766	6,113	0.829	5,951	0.661	5,840	0.997	6,593
15	0.923	8,745	1.133	8,997	1.217	8,759	0.965	8,594	1.458	9,704
20	1.227	11,659	1.511	11,995	1.626	11,678	1.29	11,459	1.951	12,938
25	1.521	14,446	1.867	14,862	2.014	14,469	1.594	14,198	2.413	16,031
30	1.804	17,203	2.224	17,699	2.392	17,230	1.899	16,907	2.874	19,090
40	2.392	22,764	2.948	23,420	3.168	22,800	2.518	22,372	3.808	25,261
50	2.99	28,454	3.682	29,274	3.965	28,500	3.147	27,965	4.762	31,576
60	3.567	33,925	4.385	34,903	4.72	33,979	3.745	33,342	5.675	37,646
75	4.427	42,135	5.455	43,349	5.864	42,202	4.658	41,410	7.049	46,756
100	5.906	56,179	7.269	57,798	7.815	56,269	6.210	55,214	9.399	62,342
Restaurant – Fast Food										
1	0.063	801	0.084	824	0.094	799	0.073	789	0.105	882

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
2	0.136	1,582	0.168	1,627	0.178	1,579	0.136	1,559	0.21	1,742
3	0.189	2,289	0.241	2,355	0.252	2,285	0.199	2,256	0.304	2,522
5	0.315	3,771	0.388	3,880	0.420	3,764	0.336	3,716	0.504	4,154
7.5	0.472	5,592	0.587	5,753	0.629	5,582	0.493	5,511	0.755	6,160
10	0.619	7,372	0.766	7,584	0.829	7,358	0.661	7,265	0.997	8,121
15	0.923	10,850	1.133	11,161	1.217	10,829	0.965	10,692	1.458	11,952
20	1.227	14,467	1.511	14,882	1.626	14,439	1.290	14,256	1.951	15,936
25	1.521	17,924	1.867	18,439	2.014	17,890	1.594	17,664	2.413	19,745
30	1.804	21,345	2.224	21,958	2.392	21,305	1.899	21,034	2.874	23,513
40	2.392	28,244	2.948	29,055	3.168	28,191	2.518	27,834	3.808	31,113
50	2.99	35,305	3.682	36,319	3.965	35,239	3.147	34,792	4.762	38,892
60	3.567	42,093	4.385	43,301	4.720	42,013	3.745	41,481	5.675	46,369
75	4.427	52,279	5.455	53,779	5.864	52,180	4.658	51,519	7.049	57,590
100	5.906	69,705	7.269	71,706	7.815	69,574	6.210	68,692	9.399	76,786
Restaurant – Sit Down										
1	0.063	613	0.084	631	0.094	619	0.073	603	0.105	680
2	0.136	1,212	0.168	1,246	0.178	1,222	0.136	1,191	0.210	1,343
3	0.189	1,754	0.241	1,803	0.252	1,769	0.199	1,723	0.304	1,944
5	0.315	2,889	0.388	2,970	0.42	2,914	0.336	2,839	0.504	3,202
7.5	0.472	4,284	0.587	4,405	0.629	4,321	0.493	4,209	0.755	4,748
10	0.619	5,647	0.766	5,806	0.829	5,696	0.661	5,549	0.997	6,259
15	0.923	8,311	1.133	8,545	1.217	8,383	0.965	8,167	1.458	9,212
20	1.227	11,082	1.511	11,394	1.626	11,178	1.290	10,889	1.951	12,283
25	1.521	13,731	1.867	14,117	2.014	13,850	1.594	13,492	2.413	15,218
30	1.804	16,351	2.224	16,811	2.392	16,493	1.899	16,067	2.874	18,123
40	2.392	21,636	2.948	22,245	3.168	21,824	2.518	21,260	3.808	23,981
50	2.99	27,045	3.682	27,806	3.965	27,280	3.147	26,575	4.762	29,976
60	3.567	32,245	4.385	33,152	4.720	32,524	3.745	31,684	5.675	35,739
75	4.427	40,048	5.455	41,175	5.864	40,395	4.658	39,351	7.049	44,387
100	5.906	53,397	7.269	54,899	7.815	53,860	6.210	52,468	9.399	59,183

Table 2-41: Deemed Energy and Demand Savings Values for Inlet Damper Part-Load Fan Control by Climate Zone

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
Hospital & HealthCare										
1	0.084	1,633	0.105	1,698	0.105	1,599	0.084	1,585	0.136	1,844
2	0.157	3,226	0.199	3,356	0.210	3,159	0.168	3,131	0.273	3,644
3	0.231	4,669	0.294	4,857	0.304	4,572	0.241	4,531	0.399	5,275
5	0.378	7,692	0.483	8,001	0.504	7,533	0.399	7,465	0.650	8,689
7.5	0.556	11,406	0.713	11,864	0.745	11,170	0.587	11,069	0.976	12,885
10	0.734	15,036	0.934	15,640	0.976	14,725	0.776	14,592	1.280	16,986
15	1.080	22,128	1.374	23,018	1.437	21,671	1.143	21,476	1.888	24,999
20	1.448	29,504	1.836	30,691	1.920	28,895	1.521	28,634	2.518	33,331
25	1.794	36,556	2.266	38,027	2.381	35,801	1.888	35,478	3.115	41,298
30	2.129	43,533	2.706	45,284	2.832	42,633	2.245	42,249	3.703	49,179
40	2.822	57,604	3.577	59,921	3.745	56,413	2.969	55,905	4.909	65,076
50	3.525	72,005	4.469	74,901	4.678	70,516	3.713	69,881	6.137	81,345
60	4.206	85,849	5.329	89,302	5.581	84,074	4.427	83,316	7.311	96,984
75	5.224	106,623	6.619	110,911	6.934	104,418	5.497	103,478	9.084	120,453
100	6.965	142,164	8.832	147,882	9.242	139,225	7.322	137,970	12.105	160,604
Office - Large										

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
1	0.084	769	0.105	798	0.105	748	0.084	745	0.136	881
2	0.157	1,519	0.199	1,577	0.210	1,478	0.168	1,472	0.273	1,741
3	0.000	2,198	0.294	2,282	0.304	2,140	0.241	2,130	0.399	2,519
5	0.378	3,622	0.483	3,760	0.504	3,525	0.399	3,510	0.650	4,150
7.5	1.000	5,370	0.713	5,575	0.745	5,227	0.587	5,204	0.976	6,155
10	0.734	7,080	0.934	7,350	0.976	6,891	0.776	6,861	1.280	8,113
15	1.000	10,419	1.374	10,817	1.437	10,142	1.143	10,097	1.888	11,941
20	1.448	13,892	1.836	14,422	1.920	13,522	1.521	13,463	2.518	15,921
25	1.794	17,213	2.266	17,870	2.381	16,754	1.888	16,680	3.115	19,726
30	2.129	20,498	2.706	21,280	2.832	19,952	2.245	19,864	3.703	23,491
40	2.822	27,123	3.577	28,158	3.745	26,401	2.969	26,284	4.909	31,083
50	3.525	33,904	4.469	35,198	4.678	33,001	3.713	32,855	6.137	38,854
60	4.206	40,423	5.329	41,965	5.581	39,345	4.427	39,172	7.311	46,324
75	5.224	50,204	6.619	52,119	6.934	48,866	5.497	48,651	9.084	57,534
100	6.965	66,939	8.832	69,493	9.242	65,155	7.322	64,868	12.105	76,712
Office - Small										
1	0.063	695	0.084	722	0.084	672	0.073	674	0.115	797
2	0.126	1,373	0.168	1,427	0.168	1,327	0.136	1,332	0.231	1,574
3	0.189	1,987	0.241	2,065	0.252	1,921	0.199	1,928	0.336	2,279
5	0.304	3,274	0.388	3,402	0.409	3,165	0.325	3,176	0.545	3,754
7.5	0.451	4,855	0.587	5,045	0.608	4,693	0.483	4,709	0.818	5,567
10	0.598	6,400	0.766	6,650	0.797	6,187	0.64	6,208	1.070	7,339
15	1.000	9,419	1.133	9,788	1.175	9,105	0.944	9,137	1.573	10,801
20	1.175	12,559	1.511	13,050	1.563	12,141	1.259	12,183	2.108	14,401
25	1.458	15,560	1.867	16,169	1.941	15,042	1.553	15,094	2.601	17,843
30	1.741	18,530	2.224	19,255	2.308	17,913	1.846	17,975	3.105	21,248
40	2.308	24,519	2.948	25,479	3.053	23,703	2.444	23,785	4.112	28,116
50	2.874	30,649	3.682	31,849	3.818	29,629	3.063	29,731	5.130	35,145
60	3.43	36,541	4.385	37,972	4.553	35,325	3.65	35,447	6.126	41,902
75	4.259	45,384	5.444	47,161	5.654	43,873	4.532	44,025	7.605	52,042
100	5.686	60,512	7.269	62,881	7.532	58,498	6.042	58,700	10.133	69,389
Education – K-12										
1	0.031	713	0.031	737	0.031	678	0.031	690	0.052	805
2	0.052	1,408	0.073	1,456	0.063	1,340	0.063	1,364	0.094	1,591
3	0.084	2,038	0.105	2,108	0.094	1,939	0.084	1,974	0.147	2,303
5	0.126	3,358	0.168	3,473	0.157	3,195	0.147	3,253	0.241	3,794
7.5	0.189	4,979	0.252	5,150	0.231	4,737	0.210	4,823	0.346	5,626
10	0.252	6,564	0.336	6,789	0.294	6,245	0.283	6,358	0.462	7,416
15	0.378	9,660	0.493	9,991	0.441	9,191	0.420	9,358	0.682	10,914
20	0.504	12,881	0.661	13,321	0.587	12,255	0.556	12,477	0.913	14,553
25	0.619	15,959	0.818	16,505	0.724	15,184	0.682	15,459	1.122	18,031
30	0.734	19,005	0.976	19,655	0.86	18,082	0.818	18,409	1.343	21,472
40	0.976	25,148	1.290	26,008	1.143	23,927	1.080	24,360	1.773	28,412
50	1.217	31,435	1.615	32,510	1.427	29,908	1.353	30,450	2.213	35,515
60	1.458	37,478	1.920	38,761	1.699	35,658	1.615	36,304	2.643	42,343
75	1.804	46,547	2.381	48,140	2.108	44,287	2.004	45,089	3.283	52,590
100	2.413	62,063	3.178	64,187	2.811	59,050	2.675	60,119	4.374	70,119
Education – College & University										
1	0.084	797	0.105	828	0.105	774	0.084	772	0.136	914
2	0.157	1,576	0.199	1,635	0.210	1,529	0.168	1,524	0.273	1,806
3	0.231	2,280	0.294	2,367	0.304	2,213	0.241	2,206	0.399	2,614
5	0.378	3,757	0.483	3,899	0.504	3,646	0.399	3,635	0.650	4,306
7.5	0.556	5,571	0.713	5,782	0.745	5,407	0.587	5,390	0.976	6,386
10	0.734	7,344	0.934	7,623	0.976	7,128	0.776	7,105	1.280	8,418
15	1.080	10,808	1.374	11,218	1.437	10,490	1.143	10,457	1.888	12,389

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
20	1.448	14,410	1.836	14,958	1.920	13,987	1.521	13,943	2.518	16,518
25	1.794	17,855	2.266	18,533	2.381	17,330	1.888	17,275	3.115	20,467
30	2.129	21,262	2.706	22,070	2.832	20,637	2.245	20,572	3.703	24,372
40	2.822	28,134	3.577	29,204	3.745	27,308	2.969	27,222	4.909	32,250
50	3.525	35,168	4.469	36,504	4.678	34,135	3.713	34,027	6.137	40,313
60	4.206	41,929	5.329	43,523	5.581	40,698	4.427	40,569	7.311	48,063
75	5.224	52,076	6.619	54,055	6.934	50,546	5.497	50,386	9.084	59,694
100	6.965	69,434	8.832	72,073	9.242	67,394	7.322	67,181	12.105	79,592
Retail										
1	0.084	961	0.105	995	0.105	939	0.084	923	0.136	1104
2	0.157	1,898	0.199	1,966	0.210	1,856	0.168	1,824	0.273	2,181
3	0.231	2,747	0.294	2,846	0.304	2,686	0.241	2,641	0.399	3,156
5	0.378	4,525	0.483	4,689	0.504	4,425	0.399	4,350	0.650	5,200
7.5	0.556	6,711	0.713	6,953	0.745	6,562	0.587	6,450	0.976	7,711
10	0.734	8,846	0.934	9,166	0.976	8,651	0.776	8,503	1.280	10,165
15	1.080	13,019	1.374	13,489	1.437	12,732	1.143	12,515	1.888	14,959
20	1.448	17,359	1.836	17,986	1.920	16,975	1.521	16,686	2.518	19,946
25	1.794	21,508	2.266	22,284	2.381	21,033	1.888	20,674	3.115	24,713
30	2.129	25,613	2.706	26,537	2.832	25,047	2.245	24,620	3.703	29,429
40	2.822	33,892	3.577	35,115	3.745	33,142	2.969	32,578	4.909	38,942
50	3.525	42,365	4.469	43,893	4.678	41,428	3.713	40,722	6.137	48,677
60	4.206	50,510	5.329	52,332	5.581	49,393	4.427	48,551	7.311	58,036
75	5.224	62,733	6.619	64,996	6.934	61,345	5.497	60,300	9.084	72,080
100	6.965	83,643	8.832	86,661	9.242	81,794	7.322	80,400	12.105	96,107
Restaurant – Fast Food										
1	0.084	1198	0.105	1243	0.105	1169	0.084	1158	0.136	1368
2	0.157	2,368	0.199	2,456	0.210	2,310	0.168	2,287	0.273	2,703
3	0.231	3,427	0.294	3,555	0.304	3,344	0.241	3,310	0.399	3,913
5	0.378	5,646	0.483	5,856	0.504	5,508	0.399	5,454	0.650	6,446
7.5	0.556	8,372	0.713	8,684	0.745	8,168	0.587	8,087	0.976	9,558
10	0.734	11,037	0.934	11,447	0.976	10,768	0.776	10,661	1.280	12,600
15	1.08	16,243	1.374	16,847	1.437	15,847	1.143	15,690	1.888	18,544
20	1.448	21,657	1.836	22,463	1.920	21,130	1.521	20,920	2.518	24,725
25	1.794	26,834	2.266	27,832	2.381	26,180	1.888	25,920	3.115	30,635
30	2.129	31,955	2.706	33,143	2.832	31,176	2.245	30,866	3.703	36,481
40	2.822	42,284	3.577	43,856	3.745	41,253	2.969	40,843	4.909	48,273
50	3.525	52,854	4.469	54,820	4.678	51,566	3.713	51,054	6.137	60,342
60	4.206	63,016	5.329	65,360	5.581	61,480	4.427	60,870	7.311	71,943
75	5.224	78,265	6.619	81,176	6.934	76,358	5.497	75,600	9.084	89,352
100	6.965	104,354	8.832	108,235	9.242	101,810	7.322	100,799	12.105	119,136
Restaurant – Sit Down										
1	0.084	914	0.105	947	0.105	903	0.084	879	0.136	1050
2	0.157	1,806	0.199	1,872	0.210	1,783	0.168	1,737	0.273	2,074
3	0.231	2,615	0.294	2,709	0.304	2,581	0.241	2,514	0.399	3,002
5	0.378	4,307	0.483	4,463	0.504	4,252	0.399	4,142	0.650	4,945
7.5	0.556	6,387	0.713	6,618	0.745	6,306	0.587	6,141	0.976	7,333
10	0.734	8,420	0.934	8,725	0.976	8,313	0.776	8,096	1.280	9,666
15	1.080	12,391	1.374	12,841	1.437	12,234	1.143	11,915	1.888	14,226
20	1.448	16,522	1.836	17,121	1.920	16,312	1.521	15,887	2.518	18,968
25	1.794	20,471	2.266	21,213	2.381	20,210	1.888	19,684	3.115	23,502
30	2.129	24,377	2.706	25,261	2.832	24,067	2.245	23,440	3.703	27,987
40	2.822	32,257	3.577	33,426	3.745	31,847	2.969	31,017	4.909	37,033
50	3.525	40,321	4.469	41,783	4.678	39,808	3.713	38,771	6.137	46,292
60	4.206	48,073	5.329	49,816	5.581	47,462	4.427	46,225	7.311	55,192
75	5.224	59,706	6.619	61,871	6.934	58,947	5.497	57,411	9.084	68,547

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
100	6.965	79,609	8.832	82,494	9.242	78,596	7.322	76,549	12.105	91,396

Table 2-42: Deemed Energy and Demand Savings Values for Inlet Guide Vane Part-Load Fan Control by Climate Zone

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
Hospital & HealthCare										
1	0.010	337	0.021	353	0.021	323	0.010	321	0.021	391
2	0.031	665	0.031	698	0.031	639	0.031	635	0.052	773
3	0.042	963	0.052	1,010	0.052	925	0.042	919	0.073	1,119
5	0.063	1,586	0.084	1,664	0.084	1,523	0.073	1,514	0.115	1,844
7.5	0.105	2,352	0.126	2,468	0.126	2,259	0.105	2,245	0.178	2,734
10	0.136	3,100	0.168	3,254	0.168	2,978	0.136	2,959	0.231	3,604
15	0.199	4,563	0.241	4,789	0.241	4,383	0.199	4,355	0.346	5,304
20	0.262	6,084	0.325	6,385	0.325	5,843	0.273	5,807	0.451	7,073
25	0.325	7,538	0.399	7,911	0.399	7,240	0.336	7,195	0.566	8,763
30	0.388	8,976	0.483	9,420	0.472	8,622	0.399	8,568	0.671	10,435
40	0.504	11,878	0.629	12,465	0.629	11,409	0.524	11,338	0.892	13,808
50	0.629	14,847	0.787	15,582	0.776	14,261	0.661	14,172	1.112	17,261
60	0.755	17,702	0.944	18,577	0.934	17,002	0.787	16,897	1.322	20,579
75	0.944	21,985	1.164	23,073	1.154	21,117	0.976	20,986	1.647	25,559
100	1.248	29,314	1.563	30,764	1.542	28,156	1.301	27,981	2.192	34,079
Office - Large										
1	0.010	157	0.021	164	0.021	149	0.010	149	0.021	185
2	0.031	311	0.031	324	0.031	294	0.031	295	0.052	365
3	0.042	449	0.052	469	0.052	426	0.042	427	0.073	528
5	0.063	741	0.084	773	0.084	702	0.073	704	0.115	870
7.5	0.105	1,098	0.126	1,146	0.126	1,040	0.105	1,043	0.178	1,290
10	0.136	1,448	0.168	1,511	0.168	1,371	0.136	1,375	0.231	1,700
15	0.199	2,130	0.241	2,223	0.241	2,018	0.199	2,024	0.346	2,502
20	0.262	2,841	0.325	2,964	0.325	2,691	0.273	2,699	0.451	3,336
25	0.325	3,519	0.399	3,673	0.399	3,334	0.336	3,344	0.566	4,134
30	0.388	4,191	0.483	4,374	0.472	3,970	0.399	3,982	0.671	4,923
40	0.504	5,546	0.629	5,788	0.629	5,254	0.524	5,269	0.892	6,514
50	0.629	6,932	0.787	7,235	0.776	6,567	0.661	6,586	1.112	8,142
60	0.755	8,265	0.944	8,626	0.934	7,830	0.787	7,853	1.322	9,708
75	0.944	10,265	1.164	10,713	1.154	9,724	0.976	9,753	1.647	12,057
100	1.248	13,687	1.563	14,284	1.542	12,966	1.301	13,004	2.192	16,076
Office - Small										
1	0.010	142	0.01	149	0.01	134	0.010	135	0.021	167
2	0.021	281	0.031	293	0.031	264	0.021	267	0.042	330
3	0.031	407	0.042	425	0.042	382	0.031	387	0.063	478
5	0.052	670	0.073	700	0.073	630	0.063	637	0.094	787
7.5	0.084	993	0.105	1,037	0.105	934	0.084	944	0.147	1,167
10	0.105	1,309	0.136	1,368	0.136	1,231	0.115	1,245	0.199	1,539
15	0.157	1,927	0.199	2,013	0.199	1,811	0.168	1,832	0.283	2,264
20	0.220	2,569	0.262	2,684	0.262	2,415	0.220	2,443	0.378	3,019
25	0.262	3,183	0.336	3,325	0.325	2,992	0.283	3,027	0.472	3,741
30	0.315	3,791	0.399	3,960	0.388	3,563	0.336	3,605	0.566	4,455
40	0.420	5,016	0.524	5,240	0.514	4,715	0.441	4,770	0.745	5,895
50	0.524	6,270	0.650	6,550	0.640	5,893	0.545	5,963	0.934	7,368
60	0.629	7,475	0.776	7,809	0.766	7,027	0.650	7,109	1.112	8,785
75	0.776	9,284	0.965	9,699	0.955	8,727	0.818	8,829	1.374	10,911
100	1.038	12,379	1.290	12,932	1.269	11,636	1.080	11,772	1.836	14,548
Education – K-12										
1	0.000	146	0.010	152	0.010	136	0.000	139	0.010	170
2	0.010	289	0.010	301	0.010	268	0.010	275	0.021	336
3	0.010	418	0.021	436	0.010	388	0.010	398	0.031	487

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
5	0.021	689	0.031	718	0.021	640	0.021	655	0.042	801
7.5	0.031	1022	0.042	1,064	0.042	949	0.031	971	0.063	1,188
10	0.042	1,348	0.052	1,403	0.052	1,251	0.052	1,281	0.084	1,567
15	0.063	1,983	0.084	2,065	0.073	1,841	0.073	1,885	0.126	2,306
20	0.084	2,645	0.115	2,753	0.094	2,454	0.094	2,513	0.168	3,074
25	0.105	3,277	0.136	3,411	0.115	3,041	0.115	3,114	0.210	3,809
30	0.126	3,902	0.168	4,061	0.147	3,621	0.136	3,708	0.252	4,536
40	0.168	5,163	0.220	5,374	0.189	4,792	0.189	4,906	0.325	6,003
50	0.210	6,454	0.273	6,718	0.241	5,990	0.231	6,133	0.409	7,503
60	0.252	7,695	0.325	8,009	0.283	7,142	0.273	7,312	0.483	8,946
75	0.315	9,557	0.409	9,948	0.357	8,870	0.336	9,082	0.608	11,110
100	0.420	12,742	0.545	13,263	0.472	11,826	0.451	12,109	0.808	14,814
Education – College & University										
1	0.010	163	0.021	170	0.021	154	0.010	155	0.021	192
2	0.031	322	0.031	336	0.031	304	0.031	305	0.052	378
3	0.042	466	0.052	486	0.052	440	0.042	442	0.073	548
5	0.063	768	0.084	801	0.084	725	0.073	728	0.115	902
7.5	0.105	1,139	0.126	1,188	0.126	1,075	0.105	1,080	0.178	1,338
10	0.136	1,501	0.168	1,566	0.168	1,418	0.136	1,423	0.231	1,764
15	0.199	2,209	0.241	2,305	0.241	2,086	0.199	2,095	0.346	2,596
20	0.262	2,946	0.325	3,073	0.325	2,782	0.273	2,793	0.451	3,462
25	0.325	3,650	0.399	3,808	0.399	3,447	0.336	3,461	0.566	4,289
30	0.388	4,346	0.483	4,534	0.472	4,105	0.399	4,121	0.671	5,108
40	0.504	5,751	0.629	6,000	0.629	5,431	0.524	5,454	0.892	6,759
50	0.629	7,189	0.787	7,500	0.776	6,789	0.661	6,817	1.112	8,448
60	0.755	8,571	0.944	8,942	0.934	8,094	0.787	8,128	1.322	10,072
75	0.944	10,645	1.164	11,105	1.154	10,053	0.976	10,094	1.647	12,510
100	1.248	14,193	1.563	14,807	1.542	13,404	1.301	13,459	2.192	16,680
Retail										
1	0.010	196	0.021	204	0.021	187	0.01	185	0.021	231
2	0.031	388	0.031	403	0.031	370	0.031	365	0.052	457
3	0.042	561	0.052	584	0.052	535	0.042	528	0.073	661
5	0.063	924	0.084	962	0.084	882	0.073	870	0.115	1,090
7.5	0.105	1,371	0.126	1,427	0.126	1,307	0.105	1,290	0.178	1,616
10	0.136	1,807	0.168	1,881	0.168	1,723	0.136	1,700	0.231	2,130
15	0.199	2,659	0.241	2,768	0.241	2,536	0.199	2,502	0.346	3,135
20	0.262	3,546	0.325	3,690	0.325	3,382	0.273	3,336	0.451	4,179
25	0.325	4,393	0.399	4,572	0.399	4,190	0.336	4,134	0.566	5,178
30	0.388	5,232	0.483	5,445	0.472	4,990	0.399	4,923	0.671	6,166
40	0.504	6,923	0.629	7,205	0.629	6,602	0.524	6,514	0.892	8,160
50	0.629	8,653	0.787	9,006	0.776	8,253	0.661	8,142	1.112	10,200
60	0.755	10,317	0.944	10,738	0.934	9,840	0.787	9,708	1.322	12,161
75	0.944	12,814	1.164	13,336	1.154	12,221	0.976	12,057	1.647	15,103
100	1.248	17,085	1.563	17,782	1.542	16,294	1.301	16,076	2.192	20,138
Restaurant – Fast Food										
1	0.010	246	0.021	256	0.021	234	0.010	233	0.021	288
2	0.031	485	0.031	506	0.031	463	0.031	460	0.052	569
3	0.042	702	0.052	733	0.052	669	0.042	666	0.073	824
5	0.063	1,157	0.084	1,207	0.084	1,103	0.073	1,096	0.115	1,357
7.5	0.105	1,716	0.126	1,790	0.126	1,635	0.105	1,626	0.178	2,012
10	0.136	2,262	0.168	2,359	0.168	2,156	0.136	2,143	0.231	2,653
15	0.199	3,329	0.241	3,472	0.241	3,173	0.199	3,154	0.346	3,904
20	0.262	4,438	0.325	4,630	0.325	4,230	0.273	4,206	0.451	5,206
25	0.325	5,499	0.399	5,737	0.399	5,242	0.336	5,211	0.566	6,450
30	0.388	6,549	0.483	6,831	0.472	6,242	0.399	6,205	0.671	7,681

HP	Dallas		El Paso		Houston		San Antonio		Amarillo	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh
40	0.504	8,665	0.629	9,040	0.629	8,259	0.524	8,211	0.892	10,164
50	0.629	10,832	0.787	11,299	0.776	10,324	0.661	10,264	1.112	12,704
60	0.755	12,914	0.944	13,472	0.934	12,309	0.787	12,237	1.322	15,147
75	0.944	16,039	1.164	16,732	1.154	15,288	0.976	15,199	1.647	18,812
100	1.248	21,386	1.563	22,309	1.542	20,384	1.301	20,265	2.192	25,083
Restaurant – Sit Down										
1	0.010	187	0.021	195	0.021	180	0.01	176	0.021	220
2	0.031	369	0.031	385	0.031	356	0.031	348	0.052	435
3	0.042	535	0.052	557	0.052	516	0.042	504	0.073	630
5	0.063	881	0.084	918	0.084	850	0.073	830	0.115	1,038
7.5	0.105	1,306	0.126	1,361	0.126	1,260	0.105	1,230	0.178	1,539
10	0.136	1,722	0.168	1,794	0.168	1,661	0.136	1,622	0.231	2,029
15	0.199	2,534	0.241	2,640	0.241	2,445	0.199	2,386	0.346	2,985
20	0.262	3,378	0.325	3,520	0.325	3,260	0.273	3,182	0.451	3,981
25	0.325	4,186	0.399	4,361	0.399	4,039	0.336	3,943	0.566	4,932
30	0.388	4,985	0.483	5,193	0.472	4,809	0.399	4,695	0.671	5,873
40	0.504	6,596	0.629	6,872	0.629	6,364	0.524	6,212	0.892	7,772
50	0.629	8,245	0.787	8,590	0.776	7,955	0.661	7,766	1.112	9,714
60	0.755	9,830	0.944	10,241	0.934	9,484	0.787	9,259	1.322	11,582
75	0.944	12,209	1.164	12,720	1.154	11,780	0.976	11,499	1.647	14,385
100	1.248	16,278	1.563	16,960	1.542	15,706	1.301	15,332	2.192	19,180

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for this VFD measure is 15 years per both the PUCT-approved Texas EUL filing (Docket No. 36779) and DEER 2014 (EUL ID – HVAC-VSD-fan).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Building Type
- Climate Zone
- Fan Size
- Part-load Control Type

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Provides EUL for VFD equipment.
- PUCT Docket 40668 – Provides details on deemed savings calculations for VFDs.

Relevant Standards and Reference Sources

- ASHRAE Standard 90.1-2004
- DEER 2014 EUL Update

Document Revision History

Table 2-43: Nonresidential HVAC-VFD History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.3 NONRESIDENTIAL: BUILDING ENVELOPE

2.3.1 ENERGY STAR® Roofs Measure Overview

TRM Measure ID: NR-BE-CR

Market Sector: Commercial

Measure Category: Building Envelope

Applicable Building Types: Specific building types defined by each utility[52]

Fuels Affected: Electricity

Decision/Action Type: Retrofit (RET)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Calculators, Worksheets

Measure Description

This section presents the deemed savings methodology for the installation of an ENERGY STAR® certified roof. The installation of an ENERGY STAR® roof decreases the roofing heat transfer coefficient and reduces the solar heat transmitted to the building space. During months when cooling is required in the building, this measure decreases the cooling energy use.

Eligibility Criteria

The simplified M&V guidelines are applicable for roofs with a slope of 2.5 or less only. Reflectivity must be at least 65% at three years, have at least a 10-year life, and be listed on the ENERGY STAR® list of qualified products.[53]

Baseline Condition

A baseline is not specified in the program manuals for any of the utilities. The only utility to specify baseline requirements is EPE, in PUCT Docket No. 41070, which states that the baseline is considered to be a black ethylene propylene diene monomer (EPDM) roofing membrane with a solar reflectance of 6.2%. The building is assumed to have a ceiling with a total R-value (including construction materials) of 18. Electric AC was assumed to have an EER of 8.5, and electric heating, a COP of 1.

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[52] Building Types are specified in the Oncor and AEP calculators. These building types differ for both utilities. It is believed that the cooling EFLH changes based on the building type, but it is unclear what EFLH is being used for each.

[53] ENERGY STAR® Certified Roofs. http://www.energystar.gov/productfinder/product/certified-roof-products/. Accessed 09/11/2013.

High-Efficiency Condition

A high efficiency condition is not specified in the program manuals for any of the utilities. The only utility to specify high efficiency requirements is EPE, in PUCT Docket No. 41070 in which it was determined that to qualify for a cool roof at least 75% of the roof surface over conditioned space must be replaced by a material with a solar reflectance of at least 70%. The roof must also receive significant direct sunlight.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Across the Texas utilities, there are several ways of calculating energy and demand savings for ENERGY STAR® roofs. Oncor and AEP use the algorithms below in their calculators to calculate their savings.

$$\textbf{Demand Savings}\ [kW] = \frac{A}{COP} \times \left[\left(\frac{1}{R_{exist}+\left(\frac{1}{h_{in,air}}\right)-R_{prop}+\left(\frac{1}{h_{in,air}}\right)}\right)\left(t_o-\frac{\varepsilon\Delta R}{h_o}-t_{in}\right)+\frac{(1-\rho_{exist})E_{tP}}{R_{exist}+\left(\frac{1}{h_{in,air}}\right)h_o}-\frac{(1-\rho_{prop})E_{tP}}{R_{prop}+\left(\frac{1}{h_{in,air}}\right)h_o}\right]$$

Equation 28

$$\textbf{Energy Savings}\ [kWh] = \frac{A}{COP} \times \left[\left(\frac{1}{R_{exist}+\left(\frac{1}{h_{in,air}}\right)-R_{prop}+\left(\frac{1}{h_{in,air}}\right)}\right)\left(\sum_{i=1}^{n} t_{o,i}-n\times\frac{\varepsilon\Delta R}{h_o}-n\times t_{in}\right)+\frac{(1-\rho_{exist})\sum_{i=1}^{n}E_{t,i}}{R_{exist}+\left(\frac{1}{h_{in,air}}\right)h_o}-\frac{(1-\rho_{prop})\sum_{i=1}^{n}E_{t,i}}{R_{prop}+\left(\frac{1}{h_{in,air}}\right)h_o}\right]$$

Equation 29

Where:

A	=	*Roof Area [ft²]*
h_o	=	*coefficient of heat transfer by long-wave radiation and convection at outer surface [Btu/hr-ºF-ft²], assumed to be 3.*
COP	=	*Coefficient of Performance*

R	=	*The total thermal resistance value (R-value) of the roof [hr-ºF-ft²/Btu], See Table 2-44.*
$h_{in,air}$	=	*The heat transfer coefficient for indoor air [Btu/hr-ºF-ft²], assumed to be 1.68.*
ρ	=	*Reflectance of surface (after three years) for solar radiation*
$E_{t,P}$	=	*Total peak solar radiation incident on surface during a cooling period [Btu/hr-ft²]. See Table 2-45.*
$\Sigma E_{t,I}$	=	*The sum of the hourly solar radiation incident during a cooling period [Btu/hr-ft²]. See Table 2-45.*
n	=	*The number of total cooling hours when solar radiation exist = 636[54]*
ε	=	*Emittance of surface for solar radiation*
ΔR	=	*Difference between long-wave radiation incident on surface from sky and radiation emitted by blackbody at outdoor air temperature [Btu/hr-ft²], assumed to be 20.*
t_o	=	*Outdoor air temperature*
t_{in}	=	*Indoor air temperature, assumed to be 75ºF*

CenterPoint Electric and Xcel Energy also use calculator-based method; however, their method is slightly different, and uses the following algorithms. These algorithms are pulled from their calculator. Note that each utility should use only its approved calculations for this measure.

$$\Delta Q\left[\frac{Btu}{hr}\right] = \Delta U \times A \times \Delta T = \left(\frac{1}{R_1} - \frac{1}{R_2}\right) \times A \times \Delta T$$

Equation 30

$$\Delta T = T_{sol-air} - T_{space} = T_{oa} + \frac{\propto}{h_o} \times \frac{I_{DT}}{24} - \frac{\varepsilon \times \Delta R}{h_o} - T_{space}$$

Equation 31

$$\Delta kW = \Delta Q \times 1.0 \times \frac{1}{12,000}$$

Equation 32

$$\Delta kWh = \Delta kW \times EFLH$$

Equation 33

[54] Peak hours are set as the months of May to September, 1pm to 7pm weekdays.

Where:

A	=	*Roof Area [ft^2]*
ΔU	=	*Difference in pre- and post-retrofit overall coefficient of heat transfer*
ΔQ	=	*Heat transfer [Btu/hr]*
ΔT	=	*Temperature difference [ºF}*
R_1	=	*Thermal resistance pre-retrofit*
R_2	=	*Thermal resistance post-retrofit*
α	=	*Absorptance of surface for solar radiation*[55]
h_o	=	*Coefficient of heat transfer by long-wave radiation and convection at outer surface*[55]
I_{DT}	=	*Hourly solar radiation incident on surface*[55]*, deemed at 1,122*
ε	=	*Hemispherical emittance of the surface, assumed to be 1.0*
T_{oa}	=	*Outdoor air temperature [ºF}*
T_{sol}	=	*Sol-air temperature [ºF}*[56]
T_{space}	=	*Indoor temperature [ºF}*
ΔR	=	*Difference between long-wave radiation incident on surface from sky and surroundings and radiation emitted by blackbody at outdoor air temperature*
1.0	=	*Assumed cooling efficiency [kW/ton]*
1/12,000	=	*Conversion from Btu to Tons/hr*
EFLH	=	*Effective full load hours [hours], assumed to be 2,000 hours*

Finally, El Paso Electric uses the methodology found in Docket No. 41070. This docket outlines a deemed method for calculating savings. Their algorithm and deemed input variables used to calculate savings are shown below:

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[55] $I_{DT} = \frac{\alpha}{h_o} \times 1.15$. Per the C&I Standard Offer Program Calculator, ASHRAE recommended values for light colored surfaces = 0.15, for medium-colored surfaces = 0.23, and for dark-colored surfaces = 0.30. These values have been approximated using SHGF for a horizontal surface at 32º north latitude as described in 1993 ASHRAE Fundamentals, Chapter 27, Tables 14.

[56] Defined by ASHRAE as the temperature that would yield the same amount of heat transfer as the combination of incident solar radiation, radiant energy exchange with the surroundings, and convective heat exchange with the outdoor air.

$$\textit{Cooling Energy Savings}\left[\frac{kWh}{ft^2}\right] = \frac{1}{EER} \times \frac{(\rho_{new} - \rho_{old}) \times E_{t,cooling}}{(R_{ins} + R_{cons} + R_{airfilm}) \times h_o} \times 0.001$$

Equation 34

$$\textit{Heating Energy Penalty}\left[\frac{kWh}{ft^2}\right] = \frac{1}{COP} \times \frac{(\rho_{old} - \rho_{new}) \times E_{t,heating}}{(R_{ins} + R_{cons} + R_{airfilm}) \times h_o} \times \frac{1}{3412}$$

Equation 35

$$\textit{Total Energy Savings}^{57} = \textit{Cooling Energy Savings} - \textit{Heating Energy Penalty}$$

Equation 36

$$\textit{Peak Demand Savings}\left[\frac{kW}{ft^2}\right] = \frac{1}{EER} \times \frac{(\rho_{new} - \rho_{old}) \times l_t}{(R_{ins} + R_{cons} + R_{airfilm}) \times h_o} \times 0.001$$

Equation 37

Where:

EER	=	*Energy efficiency ratio of the buildings air conditioner [Btu/W-hr]*
$E_{t,cooling}$	=	*Total solar radiation incident on the surface throughout the time when a building is in cooling mode [Btu/ft²]*
ρ_{new}	=	*Reflectance (at three years) of the new roof membrane*
ρ_{old}	=	*Reflectance of the original roof membrane*
R_{ins}	=	*R-value of the roof insulation [h-ft²-ºF/Btu]*
R_{cons}	=	*R-value of the roof construction [h-ft²-ºF/Btu]*
$R_{airfilm}$	=	*R-value of the air film [h-ft²-ºF/Btu]*
h_o	=	*Coefficient of heat transfer by long-wave radiation and convection at outer surface*
0.001	=	*Conversion kWh per Watt-Hr*
COP	=	*Coefficient of performance of building's electric heating system*
$E_{t,heating}$	=	*Total solar radiation incident on the surface throughout the time when a building is in heating mode [Btu/ft²]*
3412	=	*Conversion Btu per kWh*

57 For buildings with electric resistance heating.

I_t = *Total solar radiation incident on the surface during the summer peak hour [Btu/ft²-hr]*

Stipulated R-values and solar data used for the calculations are presented next:

Table 2-44: R-Values of Different Material [hr-ft²-ºF/Btu][58]

Roofing Material	R-Value	Plenum	R-Value
Asbestos – cement shingles	0.21	Yes	0.61
Asphalt Roll Roofing	0.15	No	0.00
Asphalt Shingles	0.44	**Membrane**	**R-Value**
Built-up Roofing (0.375”)	0.33	Permeable Felt	0.06
Slate (0.5”)	0.05	Seal, 2 layers of mopped 15 lb felt	0.12
Wood Shingles	0.94	Sel, plastic film	0.00
Construction Material	**R-Value**	**Insulation Material**	**R-Value (per inch)**
Concrete 4”	0.08	None	0.00
Concrete 8”	1.11	Cellulose	3.70
Concrete 12”	1.23	Fiberglass	3.20
Brick 4”	0.80	Polystyrene	4.00
Wood Frame	0.10	Polyurethane	6.25
Metal Frame	0.00	Polyisocyanurate	7.00
Ceiling Material	**R-Value**		
Acoustic Tile	0.06		
Drywall Finish	0.45		
Plaster Finish	0.45		

Table 2-45: TMY2 Solar Data

Climate Zone	Peak Total Solar Radiation Incident [Btu/hr-ft²]	Total Solar Radiation Incident [Btu/ft²]
Amarillo, TX	329	124,314
Brownsville, TX	326	113,022
Dallas/Fort Worth, TX	335	117,686
Houston, TX	325	101,734
Austin, TX	342	116,511

[58] These values are listed in both the Oncor and the CalcSmart calculators, but a source for all of the values have not been provided.

Table 2-46: Deemed Values used in Algorithm for El Paso Electric[59]

Variable	Assumed Value
EER	8.5[60]
COP	1.0[61]
ρ_{new}	0.7[62]
ρ_{old}	0.062[63]
$E_{t,cooling}$	469,199[64]
$E_{t,heating}$	185,347[64]
I_t	217[65]
R_{ins}	16[66]
R_{cons}	2[67]
$R_{airfilm}$	0.92[68]
h_o	3[69]

Deemed Energy and Demand Savings Tables

The resulting deemed energy and demand savings values are presented in Table 2-47. Note that cool roofs have a negative heating impact, as reflected in the lower deemed savings value for Electric Resistance Heat versus Gas Heat.

Table 2-47: Cool Roof Deemed Savings for El Paso Electric

Region	Electric A/C and Gas Heat [kWh/ft^2]	Electric A/C and Electric Resistance Heat [kWh/ft^2]	Summer Peak (Electric A/C) [kW/ft^2]	Winter Peak (Electric Resistance Heat) [kW/ft^2]
West	0.6205	0.0099	0.0003	0.00

59 All values and their sources were found in Docket No. 41070.
60 Federal minimum for split and packaged systems, 11.25-20 tons from January 1st, 1994 through December 31st, 2009.
61 Value for electric resistance heat.
62 Minimum required by EPE Cool Roof Program.
63 Reflectance of ethylene propylene diene monomer (EPDM) rubber. Sourced from http://www.fsec.ucf.edu/en/publications/html/FSEC-CR-670-00. Accessed 09/12/2013.
64 Total global horizontal irradiance when temperature is over 65ºF (typical building's thermal balance point) per El Paso TMY3 file.
65 Total global horizontal irradiance during summer peak hour per El Paso TMY3 file.
66 IECC 2000 Table 802.2(17).
67 Typical value.
68 ASHRAE Fundamentals 2006 27.2.
69 ASHRAE Fundamentals 2006 18.22.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

Estimated Useful Life is 15 years for cool roofs, as discussed in PUCT Docket Nos. 36779 and 41070. The DEER 2014 update also provides a 15 year life for cool roofs (EUL ID – BldgEnv-CoolRoof).

Additional Calculators and Tools

Oncor Calculator: The calculator, created by Nexant, implements the savings algorithms listed above to calculate the total energy and peak demand savings. This calculator can be found on the Oncor website: https://www.oncoreepm.com/commprogram.aspx, titled E5.xlsx.

CalcSmart Energy Star® Roof: This worksheet, used by AEP, is mostly identical to the Nexant calculator. This calculator can be found on the AEP website: http://www.aepefficiency.com/cisop/downloads/Cool%20Roof%20TCC_072213.xls. Accessed 09/12/2013.

C&I Standard Offer Program Roofing Worksheet: CenterPoint and Xcel use the same method of calculating savings. This calculator can be found on the CenterPoint website: http://www.centerpointenergy.com/staticfiles/CNP/Common/SiteAssets/doc/Roofing%20Worksheet%202013.xlsx. Accessed 09/12/2013.

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Roofing Square Foot (Conditioned Area)
- Existing Roofing Amount of Insulation
- Existing Roofing Amount of Slope
- Existing Roofing Reflectance
- ENERGY STAR® Roofing Reflectance Coefficient
- ENERGY STAR® Roofing Rated Life
- ENERGY STAR® Roofing Insulation Value
- Building Type
- HVAC Equipment Type
- HVAC Equipment Rated Efficiency

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 41070 – Provides deemed energy and demand savings values for El Paso, TX.
- PUCT Docket 36779 – Provides EUL for commercial Cool Roof.

Relevant Standards and Reference Sources

- Oncor Technical Resource Manual. 2013.
- ENERGY STAR® Certified Cool Roof Products. http://www.energystar.gov/productfinder/product/certified-roof-products/. Accessed 09/12/2013.
- IECC 2000 Table 802.2(17)
- 2006 ASHRAE Fundamentals
- EUMMOT Commercial Standard Offer Program. Measurement and Verification Guidelines for Retrofit and New Construction Projects. http://www.aepefficiency.com/cisop/downloads/2013_C&I_SOP_Appendices.pdf. Accessed 09/10/2013
- DEER 2014 EUL update

Document Revision History

Table 2-48: Nonresidential Cool Roof History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1 origin
v2.0	04/18/2014	Clarified that reflectance is three years basis. Table 2-44 through Table 2-47: Rounded off values, too many insignificant digits.

2.3.2 Window Film Measure Overview

TRM Measure ID: NR-BE-WF

Market Sector: Commercial

Measure Category: Building Envelope

Applicable Building Types: All Commercial Building Types

Fuels Affected: Electricity

Decision/Action Type: Retrofit (RET)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculations, and Values (EPE-only)[70]

Savings Methodology: Calculator

Measure Description

This section presents the deemed savings methodology for the installation of window films and solar screens. The installation of window film decreases the window-shading coefficient and reduces the solar heat transmitted to the building space. During months when perimeter cooling is required in the building, this measure decreases cooling energy use. Demand and energy savings result in demand and energy use of cooling equipment.

Eligibility Criteria

This measure is applicable for window film applied to south- and west-facing windows only.

EPE states that windows with existing solar films, solar screens, or LowE coating are not eligible for this measure. Windows must be installed in a space conditioned by refrigerated air conditioning.

Baseline Condition

Baseline conditions are assumed to be single-pane clear glass, without any window film. Interior and exterior shading is acceptable, but should be recorded.[71]

EPE states that the glass should be un-shaded, with a Solar Heat Gain Coefficient (SHGC) greater than 0.66. The Baseline window area is assumed to be 10% of the floor area.

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[70] EPE's website provides a link to the CSOP Window Film Worksheet, but Docket No. 41070, which provides a method of energy savings for El Paso and similar climate zones, does not mention a calculator as a way for the utility to estimate savings. It only provides a deemed savings table based on HVAC type, per ft^2 of window area. EPE's Program Manual only mentions the algorithm method of calculating savings, which provides the same results as the calculator.

[71] EPE also states in Docket No. 41070 that the windows must NOT be shaded by existing awnings, exterior curtains, or blinds or any other shading device.

High-Efficiency Condition

The high-efficiency condition is window film installed on south- and west-facing windows.

EPE states that the solar screen material should receive significant sun exposure and must reduce SHGC by at least 65%.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

All Utilities (Except EPE)

$$Demand\ Savings_o\ [kW] = \frac{A_{film,o} \times SHGF_o \times (SC_{pre,o} - SC_{post,o})}{3413 \times COP}$$

Equation 38

$$Peak\ Demand\ Savings\ [kW] = DemandSaving_{o,max}$$

Equation 39

$$Energy\ Savings_o\ [kWh] = \frac{A_{film,o} \times SHG_o \times (SC_{pre,o} - SC_{post,o})}{3413 \times COP}$$

Equation 40

$$Energy\ Savings\ [kWh] = \sum Energy\ Savings_o$$

Equation 41

Where:

Demand Savings$_o$	=	*Peak demand savings per window orientation*
Energy Savings$_o$	=	*Energy savings per window orientation*
$A_{film,o}$	=	*Area of window film applied to orientation [ft^2]*
$SHGF_o$	=	*Peak solar heat gain factor for orientation of interest [Btu/hr-ft^2-year], See Table 2-49.*
SHG_o	=	*Solar heat gain for orientation of interest [Btu/ ft^2-year], See Table 2-49.*

SC_{pre}	=	*Shading coefficient for existing glass/interior-shading device.*
SC_{post}	=	*Shading coefficient for new film/interior-shading device*
COP	=	*Cooling equipment COP or SEER based on ASHRAE Standard 90.1-1999 or actual COP equipment, whichever is greater*
3413	=	*Conversion factor [Btu/kW]*

EPE Only

$$\boldsymbol{Energy\ Savings\ [kWh] = \frac{A_{film} \times SHG_{cool} \times (SC_{pre} - SC_{post})}{3413 \times COP_{cool}}}$$

Equation 42

$$\boldsymbol{Energy\ Penalty\ [kWh] = \frac{A_{film} \times SHG_{heat} \times (SC_{pre} - SC_{post})}{3413 \times COP_{heat}}}$$

Equation 43

$$\boldsymbol{Total\ Energy\ Savings\ [kWh] = Energy\ Savings - Energy\ Penalty}$$

Equation 44

$$\boldsymbol{Demand\ Savings\ [kW] = \frac{A_{film} \times SHGF \times (SC_{pre} - SC_{post})}{3413 \times COP_{heat}}}$$

Equation 45

Where:

A_{film}	=	*Area of window film applied to orientation [ft²]*
SHGF	=	*Peak solar heat gain factor in [Btu/hr-ft²-year], Assumed to be 220.24 Btu/hr-ft²-year.*
SHG_{cool}	=	*Solar heat gain during cooling operation in [Btu/ ft²-year], Assumed to be 102,501 Btu/ft²-year.*
SHG_{heat}	=	*Solar heat gain during heating operation in [Btu/ ft²-year], Assumed to be 284,662 Btu/ft²-year.*

SC_{pre}	=	*Shading coefficient for existing glass/interior-shading device. Assumed to be 0.680.*
SC_{post}	=	*Shading coefficient for new film/interior-shading device. Assumed to be 0.204.*
COP_{cool}	=	*Cooling equipment COP or SEER based on ASHRAE Standard 90.1-1999 or actual COP equipment, whichever is greater. Assumed to be 2.49.*
COP_{heat}	=	*Heating equipment COP or SEER based on ASHRAE Standard 90.1-1999 or actual COP equipment, whichever is greater. Assumed to 1.0.*
3413	=	*Conversion factor [Btu/kW]*

Table 2-49: Solar Heat Gain Factors[72]

Orientation	Solar Heat Gain {SHG) [Btu/ft^2-year]	Peak Hour Solar Heat Gain (SHGF) [Btu/hr-ft^2-year]
South-East	158,323	59
South-South-East	133,894	119
South	120,095	164
South-South-West	133,894	189
South-West	158,323	219
West-South-West	168,978	228
West	162,388	220
West-North-West	139,995	208
North-West	106,876	176

Deemed Energy and Demand Savings Tables

Table 2-50: Solar Screen Deemed Savings for EPE (Climate Zone 5)

Utility	DX Coils with Gas Furnace [kWh/ft^2]	DX Coils Electric Resistance [kWh/ft^2]	Summer Peak (DX Coils) [kW/ft^2]	Winter Peak (Electric Resistance) [kW/ft^2]
EPE	15.94	1.64	0.013	0.0

[72] SHGF are based on amount of solar radiation transmitted through single-pane clear glass for a cloudless day at 32ºN Latitude for the 21st day of each month by hour of day and solar orientation. These have been aggregated into daily totals for weekdays during the months of April through October.

Measure Life and Lifetime Savings

Estimated Useful Life is 10 years for solar screens, as discussed in PUCT Docket Nos. 36779 and 41070. The DEER 2014 update also provides an EUL of 10 years for this measure (EUL ID – GlazDaylt-WinFilm).

Additional Calculators and Tools

Oncor Calculator: The calculator, created by Nexant, implements the savings algorithms listed above to calculate the total energy and peak demand savings.

CSOP Window Film Worksheet: This worksheet, used by AEP, is mostly identical to the Nexant calculator.

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Existing Window Shading Coefficients
- Existing Window Interior Shading Type
- Description of Existing Window Presence of Exterior Shading from other Buildings or Obstacles
- Window Film Shading Coefficient
- Window Film Application Area
- Cooling Equipment Type
- Cooling Equipment Rated Efficiency
- Direction Window is Facing

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 41070 – Provides deemed energy and demand savings values for El Paso, TX.
- PUCT Docket 36779 – Provides EUL for commercial Cool Roof.

Relevant Standards and Reference Sources

- 1997 ASHRAE Fundamentals, Chapter 29, Table 17.
- ASHRAE Standard 90.1-1999

- EUMMOT Commercial Standard Offer Program. Measurement and Verification Guidelines for Retrofit and New Construction Projects. http://www.aepefficiency.com/cisop/downloads/2013_C&I_SOP_Appendices.pdf. Accessed 09/10/2013
- Oncor Technical Resource Manual. 2013.
- El Paso Electric. Commercial Standard Offer Program. Measurement and Verification Guidelines for Retrofit and New Construction Projects. http://www.epelectricefficiency.com/files/EPE_MV_Guidelines_2013_110512_final.pdf. Accessed 09/11/2013
- DEER 2014 EUL update

Document Revision History

Table 2-51: Nonresidential Window Film History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Eliminated east-facing windows from consideration for energy savings.

2.4 NONRESIDENTIAL: FOOD SERVICE EQUIPMENT

2.4.1 High Efficiency Combination Ovens Measure Overview

TRM Measure ID: NR-FS-CO

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Business Types: See Table 2-53 and Table 2-54

Fuels Affected: Electricity

Decision/Action Type: Replace-on-Burnout or New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Engineering estimates, Algorithms

Measure Description

This section presents the deemed savings methodology for the installation of High Efficiency Combination Ovens. Combination ovens are convection ovens that include the added capability to inject steam into the oven cavity and typically offers at least three distinct cooking modes; combination made to roast or bake with moist heat, convection mode to operate purely as a convection oven providing dry heat, or as a straight pressure-less steamer. The energy and demand savings are determined on a per-oven basis.

Eligibility Criteria

Eligible equipment must have a heavy load cooking efficiency of at least 60% as determined by American Society for Testing and Materials (ASTM) Standard Test Models.

Baseline Condition

A standard-efficiency combination oven as defined by the Food Service Technology Center (FSTC) and reflected by the default values from the FSTC Electric Combination Oven Life-cycle Cost Calculator[73] and are listed in Table 2-52. The baseline equipment is assumed to have a heavy-load cooking efficiency of 40%.

The following parameters are used by the FSTC calculator to calculate energy consumption of ovens. Their descriptions are as follows:

- Number of steam pans: Total number of standard size steam pans the oven can hold.

[73] Food Service Technology Center. Electric Combination Oven Life-Cycle Cost Calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php. Accessed 09/08/2013.

- Preheat Energy: The total amount of energy consumed by the appliance as it warms from room temperature to a ready-to-cook condition.
- Convection Mode Idle Energy Rate. The rate the oven consumes energy while holding or maintaining a stabilized temperature with the oven operating in convection (heat-only) mode.
- Convection Mode Cooking-Energy Efficiency. The amount of energy imparted to the food being cooked divided by the energy consumed by the oven while cooking in convection (heat-only) mode.
- Convection Mode Production Capacity. The maximum production rate of the oven while cooking in convection (heat-only) mode in accordance with the heavy-load cooking test.
- Steam Mode Idle Energy Rate. The rate the oven consumes energy while holding or maintaining a stabilized temperature with the oven operating in steam-only mode.
- Steam Mode Cooking-Energy Efficiency. The amount of energy imparted to the food being cooked divided by the energy consumed by the oven while cooking in steam-only mode.
- Steam Mode Production Capacity. The maximum production rate of the oven while cooking in steam-only mode in accordance with the heavy-load cooking test.
- Water Consumption Rate. The average rate the appliance consumes water while cooking in accordance with the heavy-load cooking test.

High-Efficiency Condition

New, electric combination ovens with a heavy load cooking efficiency of at least 60% as determined by American Society for Testing and Materials (ASTM) Standard Test Models.

Table 2-52: Assumptions for Baseline and High-Efficiency Electric Combination Ovens[74]

Inputs	Baseline	High-Efficiency
Number of Steam Pans	15	15
Preheat Energy [kWh]	3.75	2.00
Convection Mode Idle Energy Rate [kW]	3.75	2.50
Convection Mode Cooking-Energy Efficiency [%]	65%	70%
Convection Mode Production Capacity [lbs/hr]	100	125
Steam Mode Idle Energy Rate [kW]	12.5	6.0
Steam Mode Cooking-Energy Efficiency [%]	40%	50%
Steam Mode Production Capacity [lbs/hr]	150	200
Water Consumption Rate [gal/hr]	40	20

[74] Default values from the FSTC Electric Combination Oven Life-Cycle Cost Calculator. These values are used to calculate Energy and Peak Demand Savings using the equations below.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The calculation for these deemed values are calculated based on the following algorithms:

$$Energy\ [kWh] = kWh_{base} - kWh_{post}$$

Equation 46

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{t_{hrs} \times t_{days}} \times CF$$

Equation 47

Where:

kWh_{base}	=	*Annual energy consumption of baseline equipment using FSTC default values*
kWh_{post}	=	*Annual energy consumption of energy efficient equipment using FSTC default values.*
t_{days}	=	*Facility operating days per year*
t_{hours}	=	*Equipment operating hours per day*
CF	=	*Peak coincidence factor*

Deemed Energy and Demand Savings Tables

The energy and demand savings of High Efficiency Combination Ovens are deemed values. The following tables provide these deemed values.

Table 2-53: Annual Demand and Energy Savings with Summary of Key Parameters[75]

Facility Description	t_{hours}	t_{days}	CF[76]	kWh_{base}	kWh_{post}
Fast Food 6am-Midnight	16	360	0.92	51,542	31,781
Fast Food 24 hr	20	360	0.92	64,269	39,636
Casual Dining 3pm-11pm	6	312	0.92	17,088	10,514
Casual Dining 11am-11pm	10	312	0.92	28,118	17,322
Casual Dining 24 hr	20	360	0.92	64,269	39,636
Institutional	8	365	0.92	26,436	16,272
School	4	180	0.32	6,673	4,097

Table 2-54: Deemed Energy and Demand Savings Values by Building Type[77]

Facility Description	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Fast Food 6am-Midnight	19,761	3.154
Fast Food 24 hr	24,633	3.154
Casual Dining 3pm-11pm	6,574	3.236
Casual Dining 11am-11pm	10,796	3.187
Casual Dining 24 hr	24,633	3.154
Institutional	10,164	3.204
School	2,576	1.144

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years, consistent with ENERGY STAR® research and with the DEER 2014 EUL update (EUL ID – Cook-ElecCombOven)

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[75] The FSTC "Electric Combination Oven Life-Cycle Cost Calculator" was used to determine the annual energy consumption of both baseline and energy efficient electric combination ovens. The FSTC calculator uses oven performance parameters based on ASTM Standard Test Method F2861. The FSTC calculator default values assume equipment is operating 12 hours a day, 365 days year. In an effort to account for variations in operation of different facility kitchens, calculator inputs for equipment operating hours and annual days of operation were assumed based on the facility types shown in Table 2-53.

[76] California End Use Survey (CEUS), Building workbooks with load shapes by end use, accessed July, 12 2012, http://capabilities.itron.com/CeusWeb/Chart.aspx.

[77] Energy and Peak Demand savings reported in PUCT Docket No. 40669. The savings reported here are based off of the assumed baseline and high efficiency values found in Table 2-52.

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Building Type
- Post-Retrofit Make and Model
- Post-Retrofit Heavy Load Cooking Efficiency

For different facility types or specific applications, the methodology presented in this work paper can be followed, provided the following additional parameters are collected and documented:

- Annual Days of Equipment Operation
- Equipment Operating Hours per Day
- Amount of Food Cooked per Day
- Coincidence Factor

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

- FSTC requirements for Commercial Combination Ovens. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php
- DEER 2014 EUL update

Document Revision History

Table 2-55: Nonresidential High-Efficiency Combination Oven History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.4.2 High Efficiency Electric Convection Ovens Measure Overview

TRM Measure ID: NR-FS-CV

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Table 2-59

Fuels Affected: Electricity

Decision/Action Type: Retrofit and New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Look-up Tables

Measure Description

This section covers the savings from retrofit (early retirement), replacement, or new installation of a full-size high efficiency electric convection oven. Convection ovens cook their food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. The energy and demand savings are deemed, and based off of energy rates of the oven, cooking efficiencies, operating hours, production capacities and building type. An average energy and demand consumption has been calculated based on these default values to create a stipulated savings value. These savings are determined on a per-oven basis.

Eligibility Criteria

Convection ovens eligible for rebate do not include ovens that have the ability to heat the cooking cavity with saturated or superheated steam. Maximum water consumption within the oven cavity must not exceed 0.25 gallons/hour. Eligible units must meet ENERGY STAR® qualifications.

Baseline Condition

Baseline oven assumptions are default operation parameters taken from the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment[78], and are listed below in Table 2-56.

[78] ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xlsx. Accessed 09/09/2013.

Table 2-56: Baseline Assumptions for Electric Convection Ovens

Inputs	Values
Oven Size	Full-Size
Preheat Energy Rate [W]	6,000
Idle Energy Rate [W]	2,000
Heavy-Load Energy Efficiency [%]	65%

High-Efficiency Condition

New, full size electric convection ovens with a heavy load cooking efficiency of at least 70% as determined by American Society for Testing and Materials (ASTM) Standard Test Models and an idle energy rate of 1,600 watts are eligible. The high efficiency oven is assumed to have the characteristics shown in Table 2-57 below, which are a result of the default values from the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment[78]. Full-size convection oven is a convection oven that is able to accept a minimum of five standard full-size sheet pans measuring 18x26x1-inch.

Table 2-57: High-Efficiency Assumptions for Electric Convection Ovens

Inputs	Values
Oven Size	Full-Size
Preheat Energy Rate [W]	4,000
Idle Energy Rate [W]	1,600
Heavy-Load Energy Efficiency [%]	70%

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

The deemed savings from these ovens are based on the following algorithms:

$$Energy\ [kWh] = (E_{base} - E_{HE}) \times days$$

Equation 48

$$Peak\ Demand\ [kW] = \frac{(E_{base} - E_{HE})}{T_{on}} \times CF$$

Equation 49

$$E_{base} = \frac{LB \times E_{Food}}{EFF_{base}} + \left[IDLE_{base} \times \left(T_{on} - \frac{LB}{PC_{base}} - \frac{TP}{60}\right)\right] + EP_{base}$$

Equation 50

$$E_{HE} = \frac{LB \times E_{Food}}{EFF_{HE}} + \left[IDLE_{HE} \times \left(T_{on} - \frac{LB}{PC_{HE}} - \frac{TP}{60}\right)\right] + EP_{HE}$$

Equation 51

Where:

E_{base} = *Baseline daily energy consumption (kWh/day)*

E_{HE}	=	*High efficiency daily energy consumption (kWh/day)*
LB	=	*Pounds of food cooked per day [lb/day]*
Days	=	*Number of operating days per year [days/yr]*
CF	=	*Coincidence Factor*
Efood	=	*ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]*
EFF_{base}	=	*Baseline heavy load cooking energy efficiency [%]*
EFF_{HE}	=	*High efficiency heavy load cooking energy efficiency [%]*
$IDLE_{base}$	=	*Baseline idle energy rate [kW]*
$IDLE_{HE}$	=	*High efficiency idle energy rate [kW]*
T_{on}	=	*Operating hours per day [hrs/day]*
PC_{base}	=	*Baseline production capacity [lbs/hr]*
PC_{HE}	=	*High efficiency production capacity [lbs/hr]*
EP_{base}	=	*Baseline preheat energy rate [kWh]*
EP_{HE}	=	*High efficiency preheat energy rate [kWh]*
TP	=	*Preheat time [min/day]*

Table 2-58: Deemed Variables for Energy and Demand Savings Calculations[79]

Variable	Deemed Values
LB[81]	Fast Food 6am-Midnight: 133 Fast Food 24hr: 167 Casual Dining 3pm-11pm: 50 Casual Dining 11am-11pm: 83 Casual Dining 24hr: 167 Institutional: 67 School: 33

[79] The FSTC "Electric Combination Oven Life-Cycle Cost Calculator" was used to determine the annual energy consumption of both baseline and energy efficient electric combination ovens. The FSTC calculator uses oven performance parameters based on ASTM Standard Test Method F2861. The FSTC calculator default values assume equipment is operating 12 hours a day, 365 days year. In an effort to account for variations in operation of different facility kitchens, calculator inputs for equipment operating hours and annual days of operation were assumed based on the facility types shown in Table 2-59.

Variable	Deemed Values
Days	Fast Food 6am-Midnight: 360 Fast Food 24hr: 360 Casual Dining 3pm-11pm: 312 Casual Dining 11am-11pm: 312 Casual Dining 24hr: 360 Institutional: 365 School: 180
CF[80]	Fast Food 6am-Midnight: 0.92 Fast Food 24hr: 0.92 Casual Dining 3pm-11pm: 0.92 Casual Dining 11am-11pm: 0.92 Casual Dining 24hr: 0.92 Institutional: 0.92 School: 0.32
E_{food}[81]	73.2
EFF_{base}[81]	65%
EFF_{HE}[81]	70%
$IDLE_{base}$[81]	2.0%
$IDLE_{HE}$[81]	1.6%
T_{on}	Fast Food 6am-Midnight: 16 Fast Food 24hr: 20 Casual Dining 3pm-11pm: 6 Casual Dining 11am-11pm: 10 Casual Dining 24hr: 20 Institutional: 8 School: 4
PC_{base}[81]	70
PC_{HE}[81]	80
EP_{base}[81]	1.5
EP_{HE}[81]	1.0
TP[81]	15

80 California End Use Survey (CEUS), Building workbooks with load shapes by end use, accessed July12, 2012, http://capabilities.the EM&V team.com/CeusWeb/Chart.asnx.
81 Default values in ENERGY STAR® calculator for Full Size Ovens.

Deemed Energy and Demand Savings Tables

The energy and demand savings of High Efficiency Convection Ovens are deemed values based on an assumed capacity for the average convection oven installed The following tables provide these deemed values.

Table 2-59: Deemed Energy and Demand Savings Values by Building Type

Facility Description	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Fast Food 6am-Midnight	2,423	0.394
Fast Food 24 hr	2,992	0.378
Casual Dining 3pm-11pm	865	0.427
Casual Dining 11am-11pm	1,359	0.394
Casual Dining 24 hr	2,992	0.378
Institutional	1,301	0.411
School	357	0.157

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years, consistent with ENERGY STAR® research[81] and with the DEER 2014 EUL update (EUL ID – Cook-ElecConvOven).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly. For facility types listed above, the following information should be collected:

- Building Type
- High Efficiency Equipment Manufacturer and Model Number
- High Efficiency Equipment Heavy Load Cooking Efficiency

For measures not installed within the facility types listed in Table 2-59, or other specific applications, the following additional information must be collected:

- Annual days of equipment operation
- Equipment operating hours per day
- Amount of food cooked per day
- Coincidence factor

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Commercial Ovens. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO. Accessed 11/25/2013.
- ENERGY STAR® list of Qualified Commercial Ovens. http://downloads.energystar.gov/bi/qplist/Commercial_Ovens_Product_List.pdf. Accessed 11/25/2013.
- DEER 2014 EUL update

Document Revision History

Table 2-60: Nonresidential High-Efficiency Convection Oven History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.4.3 ENERGY STAR® Commercial Dishwashers Measure Overview

TRM Measure ID: NR-FS-DW

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See

Table 2-65

Fuels Affected: Electricity

Decision/Action Type: Retrofit and New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Look-up Tables

Measure Description

This document presents the deemed savings methodology for the installation of an ENERGY STAR® commercial dishwasher. Commercial dishwashers that have earned the ENERGY STAR® label are on average 25% more energy-efficient and 25% more water-efficient than standard models. The energy savings associated with ENERGY STAR® commercial dishwashers is primarily due to reduced water use and reduced need to heat water. A commercial kitchen may have external booster water heaters or booster water heaters may be internal to specific equipment. Both primary and booster water heaters may be either gas or electric; therefore, dishwasher programs need to assure the savings calculations used are appropriate for the water heating equipment installed at the participating customer's facility. The energy and demand savings are determined on a per-dishwasher basis.

Eligibility Criteria

The dishwasher must be ENERGY STAR® certified and fall under one of the following categories:

- Under Counter Dishwasher
- Stationary Rack, Single Tank, Door Type Dishwasher
- Single Tank Conveyor Dishwasher
- Multiple Tank Conveyor Dishwasher

Table 2-61 provides a description of each of these.

Table 2-61: Nonresidential ENERGY STAR® Commercial Dishwashers History

Equipment Type	Equipment Description
Under Counter Dishwasher	A machine with overall height of 38" or less, in which a rack of dishes remains stationary within the machine while being subjected to sequential wash and rinse sprays, and is designed to be installed under food preparation workspaces. Under counter dishwashers can be either chemical or hot water sanitizing, with an internal booster heater for the latter. For purposes of this specification, only those machines designed for wash cycles of 10 minutes or less can qualify for ENERGY STAR®.
Stationary Rack, Single Tank, Door Type Dishwasher	A 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. Subcategories of stationary door type machines include: single and multiple wash tank, double rack, pot, pan and utensil washers, chemical dump type and hooded wash compartment ("hood type"). Stationary rack, single tank, door type models are covered by this specification and can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
Single Tank Conveyor Dishwasher	A washing machine that employs a conveyor or similar mechanism to carry dishes through a series of wash and rinse sprays within the machine. Specifically, a single tank conveyor machine has a tank for wash water followed by a final sanitizing rinse and does not have a pumped rinse tank. This type of machine may include a pre-washing section before the washing section. Single tank conveyor dishwashers can either be chemical or hot water sanitizing, with an internal or external booster heater for the latter.
Multiple Tank Conveyor Dishwasher	A conveyor type machine that has one or more tanks for wash water and one or more tanks for pumped rinse water, followed by a final sanitizing rinse. This type of machine may include one more pre-washing sections before the washing section. Multiple tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external hot water booster heater for the latter.

Baseline Condition

Baseline assumptions of water consumption for dishwashers are default values from the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment[82] and are listed next in Table 2-62.

[82] http://www.energystar.gov/certified-products/detail/commercial_dishwashers

Table 2-62: Baseline Water Consumption in Gallons per Rack of Dishes Washed[83]

Low Temp				High Temp			
Under Counter	Door Type	Single Tank Conveyor	Multi Tank Conveyor	Under Counter	Door Type	Single Tank Conveyor	Multi Tank Conveyor
1.73	2.10	1.31	1.04	1.09	1.29	0.87	0.97

High-Efficiency Condition

Qualifying equipment must meet or exceed the ENERGY STAR® V2.0 specification. High temperature equipment sanitizes using hot water, and requires a booster heater. Booster heaters can be either gas or electric. Low temperature equipment uses chemical sanitization, and does not require a booster heater. The high efficiency dishwasher is assumed to have the characteristics shown in Table 2-63 below.

Table 2-63: High-Efficiency Requirements for Commercial Dishwashers[83]

Machine Type	Low Temperature Efficiency Requirements		High Temperature Efficiency Requirements	
	Idle Energy Rate [kW]	Water Consumption [gal/rack]	Idle Energy Rate [kW]	Water Consumption [gal/rack]
Under Counter	0.50	1.19	0.50	0.86
Stationary Single Tank Door	0.60	1.18	0.70	0.89
Single Tank Conveyor	1.50	0.79	1.50	0.70
Multiple Tank Conveyor	2.00	0.54	2.25	0.54

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The calculation for these deemed values are calculated based on the following algorithms:

$$\boldsymbol{Energy}\,[\boldsymbol{kWh}] = (V_{waterB} - V_{waterP}) \times \left(\frac{\Delta T_{DHW}}{\eta_{DHW}} + \frac{\Delta T_{boost}}{\eta_{boost}}\right) \times \rho_{water} \times C_p \times \frac{1\,W}{3.412\,\frac{Btu}{hr}} \times \frac{1kW}{1000\,W}$$

Equation 52

$$\boldsymbol{Peak\ Demand}\,[\boldsymbol{kW}] = \frac{\Delta kWh}{t_{hrs} \times t_{days}} \times CF$$

Equation 53

$$\boldsymbol{Annual\ Water\ Consumption}\ (\boldsymbol{Conventional}\ \&\ ENERGY\ STAR^{®})\ [\boldsymbol{gallons}] = V_{waterB} = t_{days} \times N_{racks} \times V_{galrackB}$$

Equation 54

[83] Table 2-62 and Table 2-63 values are provided in ENERGY STAR® v2.0.

Where:

V_{waterB}	=	*Baseline volume of water consumed per year [gallons]*
V_{waterP}	=	*Post measure volume of water consumed per year [gallons]*
t_{days}	=	*Facility operating days per year [days]*
t_{hours}	=	*Equipment operating hours per day [hours]*
N_{racks}	=	*Number of racks washed per days*
CF	=	*Peak coincidence factor*
$V_{galrackB}$	=	*Gallons of water used per rack of dishes washed for conventional dishwashers [gallons]*
$V_{galrackP}$	=	*Gallons of water used per rack of dishes washed for ENERGY STAR® dishwashers [gallons]*
ρ_{water}	=	*Density of water [lbs/gallon]*
C_p	=	*Specific heat of water [Btu/lb ºF]*
ΔT_{DHW}	=	*Inlet water temperature increase for building water heater [ºF]*
η_{DHW}	=	*Building electric water heater efficiency [%]*
ΔT_{boost}	=	*Inlet water temperature for booster water heater [ºF]*
η_{boost}	=	*Booster electric water heater efficiency [%]*

Table 2-64: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
V_{waterB}[84]	Calculated based on equations above
V_{waterP}[84]	
t_{days}[85]	Varies by building type: See Table 2-65
t_{hours}[85]	
N_{racks}	

[84] Calculated using ENERGY STAR® Calculator inputting racks washed per day and annual days of operation from Table 2-64.

[85] The current version of the ENERGY STAR® Qualified Commercial Kitchen Equipment savings calculator defaults to 365 annual days of operation for all dishwasher types, and assumes a default number of racks washed per day for each specific dishwasher type. The ENERGY STAR® default values are shown in Table 2-63. However, many facilities do not operate dishwashing equipment 365 days a year or wash the ENERGY STAR® default number of racks washed per day per dishwasher. In an effort to account for variations in operation of different facility kitchens, values for equipment annual days of operation, equipment operating hours, and number of racks washed per day were assumed based on facility operating hours and seasonal schedules.

Variable	Deemed Values
CF	
$V_{galrackB}$	See Table 2-62
$V_{galrackP}$	See Table 2-63
ρ_{water}[86]	8.2 [lbs/gallon]
C_p	1.0 [Btu/lb ºF]
ΔT_{DHW}[86]	Gas Hot Water Heaters: 0ºF Electric Hot Water Heaters: 70 ºF
η_{DHW}[86]	98%
ΔT_{boost}[86]	Gas Booster Heaters: 0 ºF Electric Booster Heaters: 40 ºF
η_{boost}[86]	98%

Table 2-65: Assumed Facility Annual Days of Operation and Racks Washed per Day for Both Low and High Temperature Dishwashers

Facility Description	t_{days}	t_{hours}	CF[87]	N_{racks}			
				Under Counter	Door Type	Single Tank Conveyor	Multiple Tank Conveyor
Fast Food 6am-Midnight	360	16	0.97	15	56	80	120
Fast Food 24 hr	360	20	0.97	19	70	100	150
Casual Dining 3pm-11pm	312	6	0.97	26	98	140	210
Casual Dining 11am-11pm	312	10	0.97	38	140	200	300
Casual Dining 24 hr	360	20	0.97	56	210	300	450
Institutional	365	8	0.97	56	210	300	450
School	180	4	0.49	19	70	100	150

Deemed Energy and Demand Savings Tables

The energy and demand savings of High Efficiency Dishwashers are deemed values based on an assumed capacity for the average convection oven installed. The following tables provide these deemed values.

[86] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 12/16/2013.
[87] California End Use Survey (CEUS), Building workbooks with load shapes by end use, accessed July 12, 2012, http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx.

Table 2-66: Deemed Energy and Peak Demand Savings Values by Building Type for Low Temperature Dishwashers Supplied with Hot Water from an Electric Hot Water Heater

Facility Description	Under Counter		Door Type		Single Tank Conveyor		Multi Tank Conveyor	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Fast Food 6am-Midnight	501	0.084	3,184	0.536	2,571	0.433	3,708	0.624
Fast Food 24 hr	634	0.085	3,980	0.536	3,214	0.433	4,635	0.624
Casual Dining 3pm-11pm	752	0.390	4,829	2.502	3,899	2.020	5,624	2.914
Casual Dining 11am-11pm	1,099	0.342	6,898	2.145	5,570	1.732	8,034	2.498
Casual Dining 24 hr	1,869	0.252	11,940	1.609	9,641	1.299	13,905	1.873
Institutional	1,895	0.629	12,105	4.021	9,774	3.247	14,098	4.683
School	317	0.216	1,990	1.354	1,607	1.093	2,317	1.577

Table 2-67: Deemed Energy and Peak Demand Savings Values by Building Type for High Temperature Dishwashers Supplied with Hot Water from an Electric Hot Water Heater Using an Electric Booster Heater

Facility Description	Under Counter		Door Type		Single Tank Conveyor		Multi Tank Conveyor	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Fast Food 6am-Midnight	335	0.056	2,175	0.366	1,321	0.222	5,011	0.844
Fast Food 24 hr	424	0.057	2,719	0.366	1,651	0.222	6,264	0.844
Casual Dining 3pm-11pm	503	0.261	3,299	1.710	2,003	1.038	7,600	3.938
Casual Dining 11am-11pm	736	0.229	4,713	1.465	2,862	0.890	10,857	3.375
Casual Dining 24 hr	1,251	0.169	8,157	1.099	4,953	0.667	18,791	2.532
Institutional	1,268	0.421	8,271	2.747	5,022	1.668	19,052	6.329
School	212	0.144	1,360	0.925	825	0.562	3,132	2.131

Table 2-68: Deemed Energy and Peak Demand Savings Values by Building Type for High Temperature Dishwashers Supplied with Hot Water from a Gas Hot Water Heater Using an Electric Booster Heater

Facility Description	Under Counter		Door Type		Single Tank Conveyor		Multi Tank Conveyor	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Fast Food 6am-Midnight	122	0.021	791	0.133	763	0.128	1,822	0.307
Fast Food 24 hr	154	0.021	989	0.133	953	0.128	2,278	0.307
Casual Dining 3pm-11pm	183	0.095	1,200	0.622	1,157	0.599	2,764	1.432
Casual Dining 11am-11pm	267	0.083	1,714	0.533	1,653	0.514	3,948	1.227
Casual Dining 24 hr	455	0.061	2,966	0.400	2,860	0.385	6,833	0.921
Institutional	461	0.153	3,008	0.999	2,900	0.963	6,928	2.301
School	77	0.053	494	0.336	477	0.324	1,139	0.775

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 11 years, consistent with ENERGY STAR® research.

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Baseline Dishwasher Type
- Baseline Make and Model Number
- Post-Retrofit Dishwasher Type
- Post-Retrofit Make and Model Number
- Building Type
- Energy Source for Primary Water Heater
- Energy Source for Booster Water Heater
- Annual Days of Operation
- Number of Racks of Dishes Washed per Day
- Coincidence Factor

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Commercial Dishwashers. http://www.energystar.gov/certified-products/detail/commercial_dishwashers. Accessed 12/16/2013.
- ENERGY STAR® maintains an online list of qualified commercial dishwashers meeting or exceeding ENERGY STAR® requirements at: http://www.energystar.gov/productfinder/product/certified-commercial-dishwashers/results. Accessed 12/16/2013.
- ENERGY STAR® v2.0 Calculator (Commercial Kitchen Equipment Savings Calculator). http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx?2f42-94a7&2f42-94a7. Accessed 12/16/2013.

Document Revision History

Table 2-69: Nonresidential ENERGY STAR® Commercial Dishwashers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 original
v2.0	04/18/2014	Update savings based on newest version of ENERGY STAR® deemed input variables.
v2.1	01/30/2015	Corrections to Water Use per Rack in Table 2-63.

2.4.4 Hot Food Holding Cabinets Measure Overview

TRM Measure ID: NR-FS-HC

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Table 2-72

Fuels Affected: Electricity

Decision/Action Type: Retrofit and New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Look-up Tables

Measure Description

This section covers the energy and demand savings resulting in the installation of ENERGY STAR® qualified hot food holding cabinets. Models that meet these ENERGY STAR® specifications incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door gaskets, auto-door closers, or Dutch doors. The insulation of the cabinet offers better temperature uniformity with the cabinet from top to bottom. The energy and demand savings are deemed, and based off of an interior volume range of the holding cabinets and the building type. An average wattage has been calculated for each volume range, half size, three quarter size, and full size. Additionally, an average hours of operation has been estimated for each building type, so achieve a stipulated savings value. These savings are determined on a per-cabinet basis.

Eligibility Criteria

Hot food holding cabinets must be ENERGY STAR® certified.[88]

Baseline Condition

Eligible baseline equipment is assumed to be a standard hot food holding cabinet with a maximum idle energy rate of 40 watts/ft^3 for all equipment sizes.

High-Efficiency Condition

Eligible equipment are set by ENERGY STAR® and based on the cabinet's interior volume. Table 2-70 summarizes efficiency requirements per ENERGY STAR® Version 2.0:

[88] A list of ENERGY STAR® qualified products can be found on the ENERGY STAR® website: http://www.energystar.gov/productfinder/product/certified-commercial-hot-food-holding-cabinets/results. Accessed 08/05/2013.

Table 2-70: ENERGY STAR® Requirements for Commercial Hot Food Holding Cabinets

Product Category	Product Interior Volume (V) [ft³]	Product Idle Energy Consumption Rate [W]
Half Size	0 < V < 13	≤ 21.5 V
Three-Quarter Size	13 ≤ V ≤ 28	≤ 2.0 V + 254.0
Full Size	28 ≤ V	≤ 3.8 V + 203.5

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

The calculation for these deemed values are calculated based on the following algorithms:

$$Energy\ [kWh] = (W_B - W_P) \times V \times \frac{1}{1000} \times t_{hrs} \times t_{days}$$

Equation 55

$$Peak\ Demand\ [kW] = (W_B - W_P) \times V \times \frac{1}{1000} \times CF$$

Equation 56

Where:

W_B = *Baseline idle energy consumption [W/ft³]*

W_P = *Idle energy consumption after installation [W/ft³]*

V = *Nominal interior volume of equipment [ft³]*

t_{hrs} = *Equipment operating hours per day [hrs]*

t_{days} = *Facility operating days per year*

CF = *Peak coincidence factor*

Table 2-71: Baseline and Energy Efficient Equipment Daily Energy Consumption

Category	Nominal Interior Volume	Baseline Equipment Idle Energy Consumption [W/ft^3][89]	Efficient Equipment Idle Energy Consumption [W/ft^3][90]
Half Size	8	40	24
Three-Quarter Size	12	40	19
Full Size	20	40	11

Table 2-72: Equipment Operating Hours per Day and Facility Operating Days per Year[91]

Facility Description	Operating Hours per Day	Facility Operating Days per Year	Peak Coincidence Factor[92]
Fast Food 6am-Midnight	16	360	0.92
Fast Food 24 hr	20	360	0.92
Casual Dining 3pm-11pm	6	312	0.92
Casual Dining 11am-11pm	10	312	0.92
Casual Dining 24 hr	20	360	0.92
Institutional	8	365	0.92
School	4	180	0.32

Deemed Energy and Demand Savings Tables

The energy and demand savings of Electric Hot Food Holding Cabinets are deemed values. The following tables provide these deemed values.

[89] ENERGY STAR® Version 2.0 Hot Food Holding Cabinet specification goes into effect on October 1, 2011. The new version increases the required efficiency from the previous requirement of 40 watts/ft^3. Current ENERGY STAR® qualified equipment averages 40-73% more efficient than 40 watts/ft^3.

[90] Average of idle energy rates for products listed on current ENERGY STAR® qualified products list for each size category. Accessed 9/15/11. http://www.energystar.Qov/ia/products/prod lists/HFHC prod list.xls.

[91] A list of common facilities, equipment operating hours and operating days was assumed. Equipment operating hours and operating days were assumed based on facility operating hours and seasonal schedules.

[92] California End Use Survey (CEUS), Building workbooks with load shapes by end use, accessed July 12 2012, http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx.

Table 2-73: Deemed Energy and Demand Savings Values by Building Type

Facility Description	Size	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Fast Food 6am-Midnight	Half	691	0.115
	Three-Quarter	1,361	0.230
	Full	3,132	0.526
Fast Food 24 hr	Half	922	0.115
	Three-Quarter	1,814	0.230
	Full	4,176	0.526
Casual Dining 3pm-11pm	Half	240	0.115
	Three-Quarter	472	0.230
	Full	1,086	0.526
Casual Dining 11am-11pm	Half	399	0.115
	Three-Quarter	786	0.230
	Full	1,810	0.526
Casual Dining 24 hr	Half	922	0.115
	Three-Quarter	1,814	0.230
	Full	4,176	0.526
Institutional	Half	374	0.115
	Three-Quarter	736	0.230
	Full	1,694	0.526
School	Half	92	0.041
	Three-Quarter	181	0.082
	Full	418	0.184

Additional Calculators and Tools

N/A

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years per the PUCT approved Texas EUL filing (Docket No. 36779), and is consistent with ENERGY STAR®'s research[93] and the DEER 2014 EUL update (EUL ID - Cook-Hold Cab)

[93] ENERGY STAR® measure life based on Food Service Technology Center (FSTC) research on available models, 2009. ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." http://www.energystar.gov/ia/business/bulkpurchasinglb sp savings calc/commercial kitchen equipment calculator.xls. Accessed 9/14/11.

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Baseline Equipment Interior Cabinet Volume
- Baseline Equipment Idle Energy Rate
- Post-Retrofit Equipment Interior Cabinet Volume
- Post-Retrofit Equipment Size (Half, Three-Quarters, Full)
- Building Type

For different facility types or specific applications, the methodology presented in the paper can be followed provided the additional parameters are collected and documented.

- Annual Days of Equipment Operation
- Equipment Operating Hours per Day
- Coincidence Factors

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications
- PUCT Docket 36779 – Provides EUL for Hot Food Holding Cabinets

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Hot Food Holding Cabinets. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COM
- DEER 2014 EUL update

Document Revision History

Table 2-74: Nonresidential Hot Food Holding Cabinets History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.4.5 ENERGY STAR® Electric Fryers Measure Overview

TRM Measure ID: NR-FS-EF

Market Sector: Commercial

Measure Category: Cooking Equipment

Applicable Building Types: See Table 2-78

Fuels Affected: Electricity

Decision/Action Type: Replace-on-Burnout or New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Values

Savings Methodology: Look-up Tables

Measure Description

This section presents the deemed savings methodology for the installation of an ENERGY STAR® Electric Fryer. Fryers which have earned the ENERGY STAR® rating, offer shorter cook times and higher production rates through advanced burner and heat exchanger designs. Fry pot insulation reduces standby losses resulting in a lower idle energy rate. The energy and demand savings are determined on a per-fryer basis.

Eligibility Criteria

Eligible equipment can be found on the ENERGY STAR® list of qualified equipment[94].

Baseline Condition

Baseline fryer assumptions are assumed to be an existing or new electric fryer ≥12 inches < 18 inches wide that does not meet ENERGY STAR® product criteria. Its operation criteria and default efficiencies are found in the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment[95], and are listed below in Table 2-75.

[94] ENERGY STAR® Qualified Commercial Fryers. List Posted on May 15th, 2012. http://www.energystar.gov/ia/products/prod_lists/Fryers_prod_list.pdf. Accessed 09/09/2013.

[95] ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xlsx. Accessed 09/09/2013.

Table 2-75: Baseline Assumptions for Electric Fryers

Inputs	Values
Cooking energy efficiency	75%
Production capacity [lbs/hr]	65
Number of preheats per day	1
Preheat length [min]	13
Preheat energy rate [W]	10,615
Idle energy rate [W]	1,050

High-Efficiency Condition

New electric fryers ≥12 inches and < 18 inches wide that meet or exceed the ENERGY STAR® requirements listed below in Table 2-76.

Table 2-76: High-Efficiency Requirements for Electric Fryers

Inputs	Values
Cooking energy efficiency	≥ 80%
Idle energy rate [W]	≤ 1,000

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The calculation for these deemed values are calculated based on the following algorithms:

$$Energy\ [kWh] = kWh_{base} - kWh_{post}$$

Equation 57

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{t_{hrs} \times t_{days}} \times CF$$

Equation 58

$$\eta_{PC} = \frac{W_{defaultFood}}{C_{CapAvg} \times t_{defaultHrs}} = \frac{150\left[\frac{lbs}{day}\right]}{\frac{65+70}{2}\left[\frac{lb}{hr}\right] \times 16\left[\frac{hr}{day}\right]} = 13.9\%$$

Equation 59

$$W_{food} = C_{pan} \times t_{OpHrs} \times \eta_{PC}$$

Equation 60

Where:

kWh_{base} = *Baseline annual energy consumption [kWh]*

kWh_{post} = *Post annual energy consumption [kWh]*

$N_{preheat}$ = *Number of preheats per day*

$t_{preheatP}$ = *Post measure length of each preheat [min]*

$t_{preheatB}$ = *Baseline length of each preheat [min]*

$E_{prerateP}$ = *Post preheat energy rate [W]*

$E_{prerateB}$ = *Baseline preheat energy rate [W]*

W_{food} = *Pounds of food cooked per day [lb/day]*

E_{food} = *ASTM energy to food [Wh/lb]*

$\eta_{cookingP}$ = *Post measure cooking energy efficiency [%]*

$\eta_{cookingB}$ = *Baseline cooking energy efficiency [%]*

E_{IdleP} = *Post measure idle energy rate [W]*

E_{IdleB} = *Baseline idle energy rate [W]*

C_{CapP} = *Post measure production capacity per pan [lb/hr]*

C_{CapB} = *Baseline production capacity per pan [lb/hr]*

t_{Days} = *Facility operating days per year [days/yr]*

t_{OpHrs} = *Average daily operating hours per day [hr]*

η_{PC} = *Percent of rated production capacity [%]*

CF = *Peak coincidence factor*

Table 2-77: Deemed Variables for Energy and Demand Savings Calculations[95]

Parameter	Baseline Value	Post Retrofit Value
kWh_{base}	See Table 2-78	
kWh_{post}		
W_{food}		
$t_{OpHours}$		
t_{Days}		
CF		
$E_{PreHeat}$	10,615	6,800
$N_{PreHeat}$	1	1
$t_{PreHeat}$	13	15
E_{food}	167	167
$\eta_{cooking}$	75%	80%
E_{idleB}	1,050	1,000
C_{Cap}	65	70
η_{PC}	13.9%	

Table 2-78: Annual Energy Consumption and Daily Food Cooked by Building Type[96]

Facility Description	t_{OpHrs}	t_{Days}	CF[97]	W_{food}	kWh_{base}	kWh_{post}
Fast Food 6am-Midnight	18	360	0.92	163	19,669	18,414
Fast Food 24 hr	20	360	0.92	181	21,763	20,394
Casual Dining 3pm-11pm	6	312	0.92	54	6,092	5,601
Casual Dining 11am-11pm	10	312	0.92	90	9,722	9,033
Casual Dining 24 hr	20	360	0.92	181	21,763	20,394
Institutional	8	365	0.92	72	9,250	8,560
School	4	180	0.32	36	2,467	2,241

Deemed Energy and Demand Savings Tables

The energy and demand savings of Electric Fryers are deemed values. The following tables provide these deemed values.

96 The pre- and post- energy values are calculated using the ENERGY STAR® calculator and the inputs from Table 2-77 and Table 2-78.

97 California End Use Survey (CEUS), Building workbooks with load shapes by end use, accessed July12, 2012, http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx.

Table 2-79: Deemed Energy and Demand Savings Values by Building Type

Facility Description	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Fast Food 6am-Midnight	1,255	0.177
Fast Food 24 hr	1,369	0.174
Casual Dining 3pm-11pm	491	0.242
Casual Dining 11am-11pm	689	0.204
Casual Dining 24 hr	1,369	0.174
Institutional	690	0.217
School	226	0.101

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years per the PUCT approved Texas EUL filing (Docket No. 36779) and by the DEER 2014 EUL update (EUL ID – Cook-ElecFryer).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Building Type
- Manufacturer and Model Number
- Fryer Width
- Verification of ENERGY STAR® certification

For different facility types, the methodology presented in this template can be followed, provided additional parameters are collected and documented.

- Annual days of equipment operation
- Equipment operating hours per day
- Amount of food cooked per day
- Coincidence factor

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications
- PUCT Docket 36779 – Provides EUL for Electric Fryers

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Electric Fryers http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COF . Accessed 09/09/2013.
- DEER 2014 EUL update

Document Revision History

Table 2-80: Nonresidential Electric Fryers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.4.6 Pre-Rinse Spray Valves Measure Overview

TRM Measure ID: NR-FS-SV

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Table 2-82

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Direct Install or Point of Sale

Deemed Savings Type: Deemed Values

Savings Methodology: Deemed

Measure Description

This document presents the deemed savings methodology for the installation of Pre-Rinse Sprayers to reduce hot water usage to save energy associated with heating the water. Water heating is assumed to be electric. The energy and demand savings are determined on a per-sprayer basis. Installation of Pre-Rinse Spray Valves to reduce energy consumption associated with heating the water.

Eligibility Criteria

Pre-rinse spray valves must have a maximum flow rate no greater than 1.25 GPM. Units must be used for commercial food preparation only.

Baseline Condition

Eligible baseline equipment is pre-rinse sprayer using 1.60 GPM.[98]

High-Efficiency Condition

Eligible equipment is a pre-rinse sprayer using 1.25 GPM or less. The sprayer should be capable of the same cleaning ability as the old sprayer.[99]

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[98] Federal standards, based on EPACT 2005 and ASTM F2324 test conditions require a base line of 1.6 GPM.

[99] FEMP Performance Requirements for Federal Purchases of Pre-Rinse Spray Valves, Based on ASTM F2324-03: Standard Test Method for Pre-Rinse Spray Valves.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The calculation for these deemed values are calculated based on the following algorithms:

$$\boldsymbol{Energy\ [kWh] = (F_B \times U_B - F_P \times U_P) \times \frac{Days}{Year} \times (T_H - T_C) \times C_H \times \frac{C_E}{Eff_E}}$$

Equation 61

$$\boldsymbol{Peak\ Demand\ [kW] = P \times (F_B \times U_B - F_P \times U_P) \times (T_H - T_C) \times C_H \times \frac{C_E}{Eff_E}}$$

Equation 62

Where:

F_B	=	*Average Baseline Flow Rate of Sprayer (GPM)*
F_P	=	*Average Post Measure Flow Rate of Sprayer (GPM)*
U_B	=	*Baseline Water Usage Duration*
U_P	=	*Post-Retrofit Water Usage Duration*
T_H	=	*Average mixed hot water (after spray valve) temperature (ºF)*
T_C	=	*Average supply (cold) water temperature (ºF)*
Days	=	*Annual facility operating days for the applications*
C_H	=	*Unit Conversion: 8.33 BTU/(Gallons-ºF)*
C_E	=	*Unit Conversion: 1 BTU = 0.00029308 kWh (1/3412)*
Eff_E	=	*Efficiency of Electric Water Heater*
P	=	*Hourly Peak Demand as percent of Daily Demand*

Table 2-81: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
F_B	1.6[98]
F_P	1.25[98,99]
$U_B = U_P$	Fast Food Restaurant: 45 min/day/unit[100] Casual Dining Restaurant: 105 min/day/unit[100] Institutional: 210 min/day/unit[100] Dormitory: 210 min/day/unit[100] K-12 School: 105 min/day/unit[101]
T_H	120[102]
T_C	69[103]
Days[104]	Fast Food Restaurant: 360 Casual Dining Restaurant: 360 Institutional: 360 Dormitory: 270 K-12 School: 193
C_H	8.33
C_E	0.00029
Eff_E	1.0
P[105]	Fast Food Restaurant: 6.81% Casual Dining Restaurant: 17.36% Institutional: 5.85% Dormitory: 17.36% K-12 School: 11.35%

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100 CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Valves.

101 Assuming that institutions (e.g., prisons, university dining halls, hospitals, nursing homes) are serving three meals a day, prorate schools by 1.5hrs to 3hrs (assuming schools serve breakfast to half of the students and lunch to all), yielding 105 minutes per day.

102 According to ASTM F2324-03 Cleanability Test, the optimal operating conditions are at 120°F. This test consists of cleaning a plate of dried tomato sauce in less than 21 seconds with 120 ± 4°F water at a specified distance from the plate. This test is performed at 60 ± 2 psi of flowing water pressure.

103 FEMP Performance Requirements for Federal Purchases of Pre-Rinse Spray Valves, Based on ASTM F2324-03: Standard Test Method for Pre-Rinse Spray Valves. Average calculated input water temperature for five Texas climate zone cities.

104 For facilities that operate year round: assume operating days of 360 days/year; For schools open weekdays except summer: 360 x(5/7) x (9/12) = 193; For dormitories with few occupants in the summer: 360 x (9/12) = 270.

105 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. The Hourly Flow Profiles given in Figure 24 on page 50.19, were reviewed and A-85 118 analyzed. The Hourly Peak Demand as a percent of the daily flow was estimated by knowing the total daily flow, the hourly flow, and the peak demand period window in Arkansas.

Deemed Energy and Demand Savings Tables

The energy and demand savings of Pre-Rinse Sprayers are deemed values. The following table provides these deemed values.

Table 2-82: Deemed Energy and Demand Savings Values by Building Type

Pre-Rinse Spray Valve Electric Savings	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Fast Food	706	0.134
Casual Dining	1,647	0.794
Institutional	3,295	0.535
Dormitory	2,471	1.589
School	883	0.519

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 5 years.[98,103] This is consistent with PUCT Docket No. 36779.

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Baseline Equipment flow-rate
- Retrofit Equipment flow-rate
- Building Type

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications. Attachment A: http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/40669_3_735684.pdf. Accessed 09/09/2013.
- PUCT Docket 36779 – Provides EUL for Pre-Rinse Sprayers

Relevant Standards and Reference Sources

N/A

Document Revision History

Table 2-83: Nonresidential Pre-Rinse Spray Valves History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Updated the baseline and post-retrofit minimum flow rate values, based on federal standards. Removed reference to a list of qualifying pre-rinse spray valves.

2.4.7 ENERGY STAR® Electric Steam Cookers Measure Overview

TRM Measure ID: NR-FS-SC

Market Sector: Commercial

Measure Category: Cooking Equipment

Applicable Building Types: See Table 2-86

Fuels Affected: Electricity

Decision/Action Type: Retrofit and New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Look-up Tables

Measure Description

This document presents the deemed savings methodology for the installation of Electric Steam Cookers. Steam cookers are available in 3, 4, 5, or 6 pan and larger capacities. ENERGY STAR® qualified units are up to 50% more efficient than standard models. They have higher production rates and reduced heat loss due to better insulation and a more efficient steam delivery system. The energy and demand savings are determined on a per-cooker basis.

Eligibility Criteria

Eligible equipment can be found on the ENERGY STAR® list of qualified equipment.[106]

Baseline Condition

Baseline oven assumptions are default values from the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment[107], assuming the existing equipment is boiler based, Cooking Energy Efficiency is 26%, and Idle Rate in Watts is 1,000W.

High-Efficiency Condition

The high efficiency electric steam cookers are assumed to be ENERGY STAR® certified and have the characteristics shown in Table 2-84.

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106 ENERGY STAR® Qualified Commercial Steam Cookers. List Posted on May 15th, 2012. http://www.energystar.gov/ia/products/prod_lists/Steamers_prod_list.pdf. Accessed 09/09/2013.

107 ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xlsx. Accessed 09/09/2013.

Table 2-84: High-Efficiency Assumptions for Electric Steam Cookers[108]

Pan Capacity	Cooking Energy Efficiency	Idle Rate [W]
3-Pan	50%	400
4-Pan	50%	530
5-Pan	50%	670
6-Pan and Larger	50%	800

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

ENERGY STAR® "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment" was used to determine the annual energy consumption of both the baseline and energy efficient electric steam cooker. The ENERGY STAR® calculator default values assume equipment is operating 12 hours a day, 365 days a year. In an effort to account for variations in operation of different facility kitchens, ENERGY STAR® calculator inputs for equipment operating hours and annual days of operation were assumed based on the facility types shown in Table 2-86.

Additionally, the ENERGY STAR® calculator assumes the amount of food cooked per day by a steam cooker is 100 pounds for a 3 pan cooker; therefore, to allow for different numbers of pans and equipment operating hours, a percent of rated production capacity was calculated using the ENERGY STAR® default values in Equation 65, Equation 66 was used to calculate the amount of food cooked per day.

$$Energy\ [kWh] = kWh_{base} - kWh_{post}$$

Equation 63

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{t_{hrs} \times t_{days}} \times CF$$

Equation 64

$$\eta_{PC} = \frac{W_{defaultFood}}{C_{CapAvg} \times t_{defaultHrs}} = \frac{100\left[\frac{lbs}{day}\right] \times \frac{1}{3}\left[\frac{1}{pan}\right]}{\frac{23.3 + 16.7}{2}\left[\frac{lb}{hr\ pan}\right] \times 12\left[\frac{hr}{day}\right]} = 13.9\%$$

Equation 65

$$W_{food} = C_{pan} \times t_{OpHrs} \times N_{pan} \times \eta_{PC}$$

Equation 66

[108] ENERGY STAR®. "Commercial Steam Cookers Key Product Criteria." Accessed 9/26/11. http://www.energystar.gov/index.cfm?c=steamcookerspr_crit_steamcookers.

Where:

kWh_{base}	=	*Annual energy consumption of baseline equipment using FSTC default values*
kWh_{post}	=	*Annual energy consumption of energy efficient equipment using FSTC default values.*
N_{pre}	=	*Number of preheats per day*
T_{pre}	=	*Length of each preheat [min]*
$E_{prerate}$	=	*Preheat energy rate [W]*
W_{food}	=	*Pounds of food cooked per day [lb/day]*
E_{food}	=	*ASTM energy to food [Wh/lb]*
η	=	*Cooking energy efficiency*
η_{tSteam}	=	*Percent of time in constant steam mode [%]*
$E_{IdleRate}$	=	*Idle energy rate [W]*
C_{pan}	=	*Production capacity per pan [lb/hr]*
N_{pan}	=	*Number of pans*
N_{OpDays}	=	*Facility operating days per year [days/yr]*
t_{OpHrs}	=	*Average daily operating hours per day [hr]*
CF	=	*Peak coincidence factor*

Table 2-85: Deemed Variables for Energy and Demand Savings Calculations[109]

Parameter	Baseline Value	Post Retrofit Value
kWh_{base}	See Table 2-86	
kWh_{post}		
W_{food}		
N_{pre}	1	1
T_{pre}	15	15
$E_{PreRate}$	6,000	6,000
E_{food}	30.8	30.8
η	26%	50%
η_{tSteam}	40%	40%
$E_{IdleRate}$	1,000	3-Pan: 400 4-Pan: 530 5-Pan: 670 6-Pan: 800
C_{pan}	23.3	16.7
N_{pan}	Equal to post equipment value	3, 4, 5, or 6
$t_{OpHours}$	Fast Food 6am-Midnight: 16 Fast Food 24hr: 20 Casual Dining 3pm-11pm: 6 Casual Dining 11am-11pm: 10 Casual Dining 24hr: 20 Institutional: 8 School: 4	
N_{OpDays}	Fast Food 6am-Midnight: 360 Fast Food 24hr: 360 Casual Dining 3pm-11pm: 312 Casual Dining 11am-11pm: 312 Casual Dining 24hr: 360 Institutional: 365 School: 180	
η_{PC}	13.9%	
CF	Fast Food 6am-Midnight: 0.92 Fast Food 24hr: 0.92 Casual Dining 3pm-11pm: 0.92 Casual Dining 11am-11pm: 0.92 Casual Dining 24hr: 0.92 Institutional: 0.92 School: 0.32	

[109] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 9/26/11. Equipment specifications from 2009 Food Service Technology Center (FSTC) research on available models. Equipment cost from 2010 EPA research on available models using AutoQuotes. http://www.energystar.gov/ia/business/bulk purchasing/bpsavings calc/commercial kitchen equipment calculator.xls.

Table 2-86: Annual Energy Consumption and Daily Food Cooked by Building Type[110]

Facility Description	N_{pan}	W_{food}	kWh_{base}	kWh_{Post}
Fast Food 6am-Midnight	3-Pan	111	25,219	10,186
	4-Pan	149	32,449	13,403
	5-Pan	186	39,657	16,637
	6-Pan and Larger	223	46,864	19,843
Fast Food 24 hr	3-Pan	139	31,483	12,633
	4-Pan	186	40,534	16,660
	5-Pan	232	49,562	20,711
	6-Pan and Larger	279	58,613	24,738
Casual Dining 3pm-11pm	3-Pan	42	8,305	3,535
	4-Pan	56	10,597	4,554
	5-Pan	70	12,888	5,582
	6-Pan and Larger	84	15,179	6,601
Casual Dining 11am-11pm	3-Pan	70	13,734	5,656
	4-Pan	93	17,603	7,377
	5-Pan	116	21,472	9,113
	6-Pan and Larger	139	25,341	10,834
Casual Dining 24 hr	3-Pan	139	31,483	12,663
	4-Pan	186	40,534	16,660
	5-Pan	232	49,562	20,711
	6-Pan and Larger	279	58,613	24,738
Institutional	3-Pan	56	12,891	5,376
	4-Pan	74	16,483	6,973
	5-Pan	93	20,098	8,596
	6-Pan and Larger	111	23,689	10,193
School	3-Pan	28	3,226	1,427
	4-Pan	37	4,086	1,810
	5-Pan	46	4,947	2,196
	6-Pan and Larger	56	5,280	2.585

[110] The pre- and post- energy values are calculated using the ENERGY STAR® calculator and the inputs from Table 2-85 and Table 2-86. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xlsx.

Deemed Energy and Demand Savings Tables

The energy and demand savings of High Efficiency Steam Cookers are deemed values. The following tables provide these deemed values.

Table 2-87: Deemed Energy and Demand Savings Values by Building Type

Facility Description	Pan Capacity	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Fast Food 6am-Midnight	3-Pan	15,033	2.464
	4-Pan	19,046	3.121
	5-Pan	23,020	3.614
	6-Pan and Larger	27,021	4.271
Fast Food 24 hr	3-Pan	18,850	2.464
	4-Pan	23,874	3.121
	5-Pan	28,851	3.614
	6-Pan and Larger	33,875	4.271
Casual Dining 3pm-11pm	3-Pan	4,770	2.300
	4-Pan	6,043	2.957
	5-Pan	7,306	3.614
	6-Pan and Larger	8,578	4.271
Casual Dining 11am-11pm	3-Pan	8,078	2.300
	4-Pan	10,226	2.957
	5-Pan	12,359	3.614
	6-Pan and Larger	14,507	4.271
Casual Dining 24 hr	3-Pan	18,850	2.464
	4-Pan	23,874	3.121
	5-Pan	28,851	3.614
	6-Pan and Larger	33,875	4.271
Institutional	3-Pan	7,515	2.300
	4-Pan	9,510	2.957
	5-Pan	11,502	3.614
	6-Pan and Larger	13,496	4.271
School	3-Pan	1,799	0.817
	4-Pan	2,276	1.021
	5-Pan	2,751	1.226
	6-Pan and Larger	3,235	1.430

Measure Life and Lifetime Savings.

The EUL has been defined for this measure as 12 years, consistent with both Energy Star® specifications and DEER 2014 EUL update (EUL ID – Cook-ElecStmCooker).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Facility Type
- Manufacturer and Model number
- Number of Pans
- Verification of ENERGY STAR® certification

For different facility types, the methodology presented in this template can be followed, provided additional parameters are collected and documented:

- Annual days of equipment operation
- Equipment operating hours per days
- Amount of food cooked per day
- Coincidence Factor

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

- ENERGY STAR® specifications for Commercial Steam Cookers. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC. Accessed 09/09/2013
- DEER 2014 EUL update

Document Revision History

Table 2-88: Nonresidential High-Efficiency Commercial Steam Cookers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Updated EUL based on Energy Star® and DEER 2014

2.5 NONRESIDENTIAL: REFRIGERATION

2.5.1 Door Heater Controls Measure Overview

TRM Measure ID: NR-RF-DC

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores.

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Look-up Tables

Measure Description

This document presents the deemed savings methodology for the installation of Door Heater Controls for glass-door refrigerated cases with anti-sweat heaters (ASH). A door heater controller senses dew point (DP) temperature in the store and modules 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 climate zones, weather data from each climate zone must be analyzed to obtain a DP profile. The reduced heating results in a reduced cooling load. The savings are on a per-linear foot of display case basis.

Eligibility Criteria

N/A

Baseline Condition

Baseline efficiency case is a cooler or a freezer door heater that operates 8,760 hours per year without any controls.

High-Efficiency Condition

Eligible high efficiency equipment is a cooler or a freezer door heater connected to a heater control system, which controls the door heaters by measuring the ambient humidity and temperature of the store, calculating the dew point (DP) temperature, and using pulse width modulation to control the anti-sweat door heater based on specific algorithms for freezer and cooler doors.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy savings from the installation of Anti-Sweat heater controls are a result from both the decrease in length of time the heater is running (kWh_{ASH}) and the reduction in load on the refrigeration (kWh_{refrig}). These savings are calculated using the following procedures:

Indoor dew point ($t_{d\text{-}in}$) can be calculated from outdoor dew point ($t_{d\text{-}out}$) using the following equation:

$$t_{d-in} = 0.005 \times t_{d-out}^2 + 0.172 \times t_{d-out} + 19.870$$

Equation 67

The baseline assumes door heats are running on 8,760 operation. In the post-retrofit case, the duty for each hourly reading is 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 42.89ºF DP and all on (duty cycle of 100%) at 52.87ºF for a typical supermarket. Between these values, the door heaters' duty cycle changes proportionally:

$$\textit{Door Heater ON}\% = \frac{t_{d-in} - \textit{All OFF setpt}\ (42.89°F)}{\textit{All ON setpt}\ (52.87°F) - \textit{All OFF setpt}\ (42.89°F)}$$

Equation 68

The controller only changes the run-time of the heaters so the instantaneous door heater power (kW_{ASH}) as a resistive load remains constant per linear foot of door heater at:

$$kW_{ASH} = \frac{115V \times 0.37\left(\frac{A}{ft}\right)}{1000} \times \textit{Linear ft of door heater} = 0.043\left(\frac{kW}{ft}\right) \times \textit{ft of door heater}$$

Equation 69

Door heater energy consumption for each hour of the year is a product of power and run-time:

$$kWh_{ASH-Hourly} = kW_{ASH} \times \textit{Door Heater ON}\% \times 1\,Hour$$

Equation 70

$$kWh_{ASH} = \sum kWh_{ASH-Hourly}$$

Equation 71

To calculate energy savings from the reduced refrigeration load using average system efficiency and assuming that 35% of the anti-sweat heat becomes a load on the refrigeration system[111], the cooling load contribution from door heaters can be given by:

$$Q_{ASH}(ton-hrs) = 0.35 \times kW_{ASH} \times \frac{3413\frac{Btu}{hr}}{12000\frac{Btu}{ton}} \times Door\ Heater\ ON\%$$

Equation 72

The compressor power requirements are based on calculated cooling load and energy-efficiency ratios obtained from 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.

For medium temperature refrigerated cases, the saturated condensing temperature (SCT) is calculated as the design dry-bulb temperature plus 15 degrees. For low temperature refrigerated cases, the SCT is the design dry-bulb temperature plus 10 degrees. The EER for both medium- and low-temperature applications is a function of SCT and part load ratio (PLR) of the compressor. PLR is the ratio of total cooling load to compressor capacity, and is assumed to be a constant 0.87[112].

For medium temperature compressors, the following equation is used to determine the EER_{MT} [Btu/hr/watts]. These values are shown in Table 2-89:

$$EER_{MT} = a + (b \times SCT) + (c \times PLR) + (d \times SCT^2) + (e \times PLR^2) + (f \times SCT \times PLR) + (g \times SCT^3) + (h \times PLR^3) + (i \times SCT \times PLR^2) + (j \times SCT^2 \times PLR)$$

Equation 73

Where:

a	=	*3.753*
b	=	*-0.050*
c	=	*29.459*
d	=	*0.0003*
e	=	*-11.771*
f	=	*-0.213*
g	=	-1.466×10^{-6}

[111] A Study of Energy Efficient Solutions for Anti-Sweat Heaters. Southern California Edison RTTC. December 1999.

[112] Work Paper PGEREF108: Anti-Sweat Heat (ASH) Controls. Pacific Gas & Electric Company. May 29,2009.

h = *6.802*

I = *-0.020*

j = *0.0007*

PLR = *0.87*

SCT = *ambient design temperature+ 15*

For low temperature compressors, the following equation is used to determine the EER_{LT} [Btu/hr/watts]:

$$\boldsymbol{EER_{LT} = a + (b \times SCT) + (c \times PLR) + (d \times SCT^2) + (e \times PLR^2) + (f \times SCT \times PLR) + (g \times SCT^3) + (h \times PLR^3) + (i \times SCT \times PLR^2) + (j \times SCT^2 \times PLR)}$$

Equation 74

Where:

a = *9.867*

b = *-0.230*

c = *22.906*

d = *0.002*

e = *-2.489*

f = *-0.248*

g = -7.575×10^{-6}

h = *2.036*

i = *-0.021*

j = *0.0009*

PLR = *0.87*

SCT = *ambient design temperature+10*

Table 2-89: Values Based on Climate Zone City

Climate Zome	Summer Design Dry Bulb Temp[113]	SCT_{MT}	SCT_{LT}	EER_{MT}	EER_{LT}
Amarillo	96	111	106	6.44	4.98
Dallas-Ft. Worth	100	115	110	6.05	4.67
El Paso	101	116	111	5.95	4.59
Houston	96	111	106	6.44	4.98
McAllen	100	115	110	6.05	4.67

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:

$$kWh_{refrig-hourly} = Q_{ASH} \times \frac{12}{EER}$$

Equation 75

$$kWh_{refrig} = \sum kWh_{refrig-Hourly}$$

Equation 76

Total annual energy consumption (direct door heaters and indirect refrigeration) is the sum of all hourly reading values:

$$kWh_{total} = kWh_{refrig} + kWh_{ASH}$$

Equation 77

Total energy savings is a result of the baseline and post-retrofit case:

$$Annual\ Energy\ Savings\ [kWh] = kWh_{total-baseline} + kWh_{total-post}$$

Equation 78

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 is calculated by the following equation:

$$Peak\ Demand\ Savings = \frac{kWh_{refrig-baseline} - kWh_{refrig-post}}{8760}$$

Equation 79

Deemed Energy and Demand Savings Tables

The energy and demand savings of Anti-Sweat Door Heater Controls are deemed values based on city and refrigeration temperature. The following table provides these deemed values.

[113] ASHRAE Climatic Region Data, 0.5% (°F).

Table 2-90: Deemed Energy and Demand Savings Values by Location and Refrigeration Temperature in kWh per Linear Foot of Display Case

Pre-Rinse Spray Valve Electric Savings	Medium Temperature		Low Temperature	
	Annual Energy Savings [kWh/ft]	Peak Demand Savings [kW/ft]	Annual Energy Savings [kWh/ft]	Peak Demand Savings [kW/ft]
Amarillo	357	0.006	373	0.008
Dallas	243	0.005	255	0.006
El Paso	395	0.008	415	0.010
Houston	176	0.003	184	0.004
McAllen	134	0.003	140	0.003

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years per the PUCT approved Texas EUL filing (Docket No. 36779). It is also consistent with the DEER 2014 EUL update (EUL ID - GrocDisp-FixtDrGask).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Regional Climate Zone
- Refrigeration Temperature

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications. Attachment A: http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/40669_3_735684.PDF. Accessed 08/08/2013. http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/40669_7_736775.PDF. Accessed 08/08/2013.
- PUCT Docket 36779 – Provides EUL for Anti-Sweat Heater Controls

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 2-91: Nonresidential Door Heater Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	In the energy savings equation used to determine the EER, rounded off the regression coefficients to 4 or 5 significant figures.
v2.1	01/30/2015	Correction to state that savings are on a per-linear foot of display case.

2.5.2 ECM Evaporator Fan Motor Measure Overview

TRM Measure ID: NR-RF-FM

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Algorithm

Measure Description

This document presents the deemed savings methodology for the installation of an Electronically Commutated Motor (ECM) in cooler and freezer display cases replacing existing evaporator fan motors. ECMs can reduce fan energy use up to approximately 65%, and can also provide higher efficiency, automatic variable-speed drive, lower motor operating temperatures, and less maintenance.

Eligibility Criteria

All ECMs must constitute suitable, size-for-size replacements of evaporator fan motors.

Baseline Condition

Baseline efficiency case is an existing shaded pole evaporator fan motor in a refrigerated case.

High-Efficiency Condition

Eligible high efficiency equipment is an electronically commutated motor which replaces an existing evaporator fan motor.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy savings from the installation of ECMs are a result of savings due to the increased efficiency of the fan, and reduction of heat produced from the reduction of fan operation. The energy and demand savings are calculated using the following equations:

$$Energy\ [kWh] = \Delta kWh_{fan} + \Delta kWh_{heat}$$

Equation 80

$$\Delta kWh_{fan} = kW_{fan} \times LRF \times Hours$$

Equation 81

$$\Delta kWh_{heat} = \Delta kWh_{fan} \times 0.28 \times Eff$$

Equation 82

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{Hours}$$

Equation 83

Where:

ΔkWh_{fan}	=	*Energy savings due to increased efficiency of evaporator fan motor*
ΔkWh_{heat}	=	*Energy savings due to reduced heat from evaporator fan*
kW_{fan}	=	*Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power adjustment/factor*[114] $kW_{fan} = \frac{RatedPower}{MotorEfficiency} \times 0.55$
LRF	=	*Load reduction factor for motor replacement*
Hours	=	*Annual operating hours, depending on whether or not the evaporator fan has controls*
0.28	=	*Conversion factor between kW and tons: 3413 Btuh/kW divided by 12,000 Btuh/ton*
Eff	=	*Estimated efficiency based on climate and refrigeration type (medium temperature or low temperature)*

[114] Conservative value based on 15 years of National Resource Management's (NRM) field observations and experience.

Table 2-92: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
LRF	65%[115]
Hours[116]	Evaporator Fans with Controls: 4,030 Evaporator Fans without Controls: 8,760
Eff_{MT}[117]	Amarillo: 1.86 Dallas-Ft. Worth: 1.98 El Paso: 2.02 Houston: 1.86 McAllen: 1.98
Eff_{LT}[117]	Amarillo: 2.41 Dallas-Ft. Worth: 2.57 El Paso: 2.61 Houston: 2.41 McAllen: 2.57

Deemed Energy and Demand Savings Tables

The energy and demand savings of ECMs are calculated using a deemed algorithm, based on city, refrigeration temperature, and whether or not the motors have controls. Evaporator fan nameplate data is also required; rated power and efficiency.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 15 years as defined by the DEER 2014 EUL update (EUL ID - GrocDisp-FEvapFanMtr & GrocWlkIn-WEvapFanMtr).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Regional Climate Zone

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[115] Small Business Services Custom Measure Impact Evaluation. Prepared for National Grid by RLW Analytics, March 23, 2007; the value is supported by National Resource Management (NRM) based on several pre-and post-meter readings of installations.

[116] The value is an estimate by National Resource Management (NRM) based on extensive analysis of hourly use data. These values are also supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet User's Manual. Prepared for NSTAR.

[117] Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.o.2007).

- Building Type
- Motor Efficiency
- Motor Power Rating
- Evaporator Fan Control Type
- Refrigeration Temperature

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 2-93: Nonresidential ECM Evaporator Fan Motors History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.5.3 Electronic Defrost Controls Measure Overview

TRM Measure ID: NR-RF-DF

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Algorithm, Engineering estimates

Measure Description

This document presents the deemed savings methodology for the installation of electronic defrost controls. The controls sense whether or not a defrost cycle is required in a refrigerated case, and skips it if it is unnecessary.

Eligibility Criteria

N/A

Baseline Condition

The baseline efficiency case is an evaporator fan defrost system that uses a time clock mechanism to initiate electronic resistance defrost.

High-Efficiency Condition

Eligible high efficiency equipment is an evaporator fan defrost system with electronic defrost controls.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy savings from the installation of electronic defrost controls are a result of savings due to the increase in operating efficiency and the reduced heat from a reduction in number of defrosts. The energy and demand savings are calculated using the following equations:

$$Energy\ [kWh] = \Delta kWh_{defrost} + \Delta kWh_{heat}$$

Equation 84

$$\Delta kWh_{defrost} = kW_{defrost} \times DRF \times Hours$$

Equation 85

$$\Delta kWh_{heat} = \Delta kWh_{defrost} \times 0.28 \times Eff$$

Equation 86

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{Hours}$$

Equation 87

Where:

$\Delta kWh_{defrost}$	=	*Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls*
ΔkWh_{heat}	=	*Energy savings due to the reduced heat from reduced number of defrosts*
$kW_{defrost}$	=	*Load of electric defrost*
Hours	=	*Number of hours defrost occurs over a year without defrost controls*
DRF	=	*Defrost reduction factor – percent reduction in defrosts required per year*
0.28	=	*Conversion of kW to tons; 3,413 Btuh/kW divided by 12,000 Btuh/ton*
Eff	=	*Estimated efficiency based on climate & refrigeration type*

Table 2-94: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
DRF[118]	35%
Eff_{MT}[119]	Amarillo: 1.86 Dallas-Ft. Worth: 1.98 El Paso: 2.02 Houston: 1.86 McAllen: 1.98
Eff_{LT}[119]	Amarillo: 2.41 Dallas-Ft. Worth: 2.57 El Paso: 2.61 Houston: 2.41 McAllen: 2.57

Deemed Energy and Demand Savings Tables

N/A

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 10 years.[120]

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Hours that defrost occurs over a year without defrost controls
- Load of electric defrost
- Refrigeration Temperature (Low Temperature or Medium Temperature)
- Climate Zone (Amarillo, Dallas-Fort Worth, El Paso, Houston, or McAllen)

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[118] Energy & Resource Solutions (2005). *Measure Life Study.* Prepared for The Massachusetts Joint Utilities; supported by 3rd party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability.

[119] Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.o.2007).

[120] Energy & Resource Solutions (2005). *Measure Life Study.* Prepared for The Massachusetts Joint Utilities.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket No. 40669 provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

N/A

Document Revision History

Table 2-95: Nonresidential Electronic Defrost Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.5.4 Evaporator Fan Controls Measure Overview

TRM Measure ID: NR-RF-FC

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Algorithm

Measure Description

This document presents the deemed savings methodology for 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.

Eligibility Criteria

N/A

Baseline Condition

Baseline efficiency case is an existing shaded pole evaporator fan motor with no temperature controls, running 8,760 annual hours.

High-Efficiency Condition

Eligible high efficiency equipment will be regarded as an energy management system (EMS) or other electronic controls to modulate evaporator fan operation based on temperature of the refrigerated space.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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:

$$\boldsymbol{Energy\ [kWh] = \Delta kW \times 8760}$$

Equation 88

$$\boldsymbol{Peak\ Demand\ [kW] =}$$

$$\boldsymbol{\left((kW_{evap} \times n_{fans}) - kW_{circ}\right) \times (1 - DC_{comp}) \times DC_{evap} \times BF}$$

Equation 89

Where:

kW_{evap}	=	*Connected load kW of each evaporator fan*
kW_{circ}	=	*Connected load kW of the circulating fan*
n_{fans}	=	*Number of evaporator fans*
DC_{comp}	=	*Duty cycle of the compressor*
DC_{evap}	=	*Duty cycle of the evaporator fan*
BF	=	*Bonus factor for reducing cooling load from replacing the evaporator fan with a lower wattage circulating fan when the compressor is not running*
8760	=	*Annual hours per year*

Table 2-96: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
kW_{evap}[121]	0.123 kW
kW_{circ}[122]	0.035 kW
DC_{comp}[123]	50%
DC_{evap}[124]	Cooler: 100% Freezer: 94%
BF[125]	Low Temp: 1.5 Medium Temp: 1.3 High Temp: 1.2

Deemed Energy and Demand Savings Tables

N/A

Measure Life and Lifetime Savings.

The EUL has been defined for this measure as 16 years per the PUCT approved Texas EUL filing (Docket No. 36779). This is consistent with the DEER 2014 EUL update (EUL ID - GrocWlkIn-WEvapFMtrCtrl).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Number of evaporator fans controlled
- Refrigeration Type

[121] Based on an a weighted average of 80% shaded pole motors at 132 watts and 20% PSC motors at 88 watts.

[122] Wattage of fan used by Freeaire and Cooltrol.

[123] 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.

[124] 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).

[125] 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.

- Refrigeration Temperature

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket No. 40669 provides energy and demand savings and measure specifications
- PUCT Docket No. 36779 provides approved EUL for Evaporator Fan Controls

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 2-97: Nonresidential Evaporator Fan Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.5.5 Night Covers for Open Refrigerated Display Cases Measure Overview

TRM Measure ID: NR-RF-RC

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Value (per linear ft of case)

Savings Methodology: Look-up Tables

Measure Description

This document presents the deemed savings methodology for the installation of night covers on otherwise open vertical (multi-deck) and horizontal (or coffin-type) low-temperature and medium-temperature 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.

Eligibility Criteria

Any suitable material sold as a night cover.

Baseline

Baseline efficiency case is an open low-temperature or medium-temperature refrigerated display case (vertical or horizontal) that is not equipped with a night cover.

High-Efficiency Condition

Eligible high efficiency equipment is considered any suitable material sold as a night cover. The cover must be applied for a period of at least 6 hours per night. Vertical strip curtains may be in use 24 hours per day.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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 work paper 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.[126]
- Infiltration accounts for approximately 24% of the total cooling load of open horizontal (coffin or tub style) display cases.[126]

Installing night covers for a period of 6 hours per night can reduce the cooling load due to infiltration by:

- 8% on vertical cases[126]
- 50% on horizontal cases[127]

The energy savings due to the reduced infiltration load when night covers are installed will vary based on outdoor temperature and climate zone. As a result the energy savings must be determined for each climate zone and typical outdoor temperatures when the covers are applied.

Once the infiltration load for each type of case was determined, the following steps were followed to determine the compressor power requirements and energy savings. It is important to reiterate that heat transfer in display cases occurs due to convection, conduction, and radiation. The analysis presented here is limited to the cooling load imposed by convection (infiltration) only and not the total cooling load of a particulate display case.

1. In the base case it is assumed that no night covers are installed on the cases and the infiltration cooling load for each bin can be given by:

$$\boldsymbol{Q_{baselineInfiltration}[ton-hours] = \frac{Q_{baselineInfiltration}[Btuh] \times Bin-hours}{12{,}000\left[\frac{Btu}{ton}\right]}}$$

Equation 90

[126] ASHRAE 2006. Refrigeration Handbook. Retail Food Store Refrigeration and Equipment. Atlanta, Georgia. p. 46.1, p. 46.5, p. 46.10.

[127] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study. 2005. Run ID D03- 205. The EM&V team, Inc. p. 7-74 and 7-75. DEER.

The compressor power requirements are based on calculated cooling load and energy-efficiency ratios (EER) obtained from manufacturers' data.

2. Determine the saturated condensing temperature (SCT)

For Medium Temperature (MT): $\boldsymbol{SCT = DB_{adj} + 15}$

Equation 91

For Low Temperature (LT): $\boldsymbol{SCT = DB_{adj} + 10}$

Equation 92

Where:

DB_{adj} = *Design dry-bulb temperature (ºF), based on climate zone, of ambient or space where the compressor/condensing units reside. Table 2-98 below lists design dry-bulb temperatures by climate zone.*

Table 2-98: Various Climate Zone Design Dry Bulb Temperatures and Representative Cities

Representative Climate Zone	Summer Design Dry Bulb Temperature, ASHRAE Climatic Region Data, 0.5% (ºF)[128]
Amarillo, TX	96
Dallas-Ft. Worth, TX	100
El Paso, TX	101
Houston, TX	96
McAllen, TX	100

3. Determine the EER for both MT and LT applications

   a. Compressor performance curves were obtained from a review of manufacturer data for reciprocating compressors as a function of SCT, cooling load, and cooling capacity of compressor.[129]

   b. Part-load ratio (PLR) is the ratio of total cooling load (from Cooling Load Calculation Section) to compressor capacity. It indicates the percentage of compressor capacity needed to remove the total cooling load. It is calculated by the following equation:

$$\boldsymbol{PLR = \frac{Q_{cooling}}{Q_{capacity}}}$$

Equation 93

[128] ASHRAE 2009 Handbook Fundamentals.

[129] Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.0.2007).

Where:

PLR	=	*Part Load Ratio*
$Q_{cooling}$	=	*Cooling Load*
$Q_{capacity}$	=	*Total Compressor Capacity*[130]

$$Q_{capacity} = Q_{cooling} \times 1.15$$

$$PLR = \frac{1}{1.15} = 0.87$$

To simplify the analysis, it is assumed that PLR remains constant for the post-retrofit condition.

c. The energy efficiency ratio (EER) is a measure of how efficient a cooling system operates at a particular temperature. It is defined as the ratio of useful energy transfer to the work input. For refrigeration systems it is the ratio of heat removed by the compressor (Btu/h) to the input power (Watts). The higher the EER the greater the efficiency of the system.

For medium temperature compressors, the following equation is used to determine the EER_{MT} (Btu/hr/watts). The equation uses SCT (from step 2), and a PLR of 0.87 (from step 3b).

$$\boldsymbol{EER_{MT} = a + (b \times SCT) + (c \times PLR) + (d \times SCT^2) + (e \times PLR^2) + (f \times SCT \times PLR) + (g \times SCT^3) + (h \times PLR^3) + (i \times SCT \times PLR^2) + (j \times SCT^2 \times PLR)}$$

Equation 94

Where:

a	=	*3.753*
b	=	*-0.050*
c	=	*29.459*
d	=	*0.0003*
e	=	*-11.771*
f	=	*-0.213*
g	=	-1.466×10^{-6}

130 Compressor capacity is determined by multiplying baseline cooling load by a compressor over-sizing factor of 15%.

h	=	*6.802*
i	=	*-0.020*
j	=	*0.0007*

d. For low temperature compressors, the following equation is used to determine the EER_{LT} (Btu/hr/watts). The equation uses SCT (from step 2), and a PLR of 0.87 (from step 3b).

$$\boldsymbol{EER_{LT} = a + (b \times SCT) + (c \times PLR) + (d \times SCT^2) + (e \times PLR^2) + (f \times SCT \times PLR) + (g \times SCT^3) + (h \times PLR^3) + (i \times SCT \times PLR^2) + (j \times SCT^2 \times PLR)}$$

Equation 95

Where:

a	=	*9.867*
b	=	*-0.230*
c	=	*22.906*
d	=	*0.002*
e	=	*-2.489*
f	=	*-0.248*
g	=	-7.575×10^{-6}
h	=	*2.036*
i	=	*-0.0215*
j	=	*0.001*

4. Convert EER to kW/ton

$$\boldsymbol{\frac{kW}{ton} = \frac{12}{EER}}$$

Equation 96

5. Energy used by the compressor to remove heat imposed due to infiltration in the base case for each bin reading is determined based on the calculated cooling load and EER, as outlined below.

$$kWh_{baseline-refrig-bin} = Q_{baseline-infiltration}[ton - hours] \times \frac{kW}{ton}$$

Equation 97

6. Total annual baseline refrigeration energy consumption is the sum of all bin values.

$$kWh_{baseline-refrig} = \sum kWh_{baseline-refrig-bin}$$

Equation 98

In the post retrofit case, it is assumed that night covers are installed on the cases during the nights from midnight to 6:00 AM. During the day the cases are uncovered and the total cooling load for each bin can be given by:

$$Q_{post-retrofit}[ton - hours] = \frac{Q_{baseline-infiltration}\,[Btuh] \times Daytime_{bin-hrs}}{12,000\,\left[\frac{Btuh}{ton}\right]} + \frac{(Q_{baseline-infiltration}\,[Btuh] - Q_{reduced-infiltration}\,[Btuh]) \times Nighttime_{bin-}}{12,000\,\left[\frac{Btuh}{ton}\right]}$$

Equation 99

Steps 2 through 7 are repeated in the post-retrofit case to calculate the post retrofit energy and demand usage.

7. TThe energy savings were determined as the difference between the baseline energy use and post-retrofit energy use:

$$\Delta kWh_{total} = kWh_{totalBaseline} - kWh_{totalPostRetrofit}$$

Equation 100

Deemed Energy and Demand Savings Tables

The energy and demand savings of Night Covers are based on PG&E Night Covers Work Paper. PG&E modeled the infiltration load of refrigerator cases without night covers and refrigerators with night covers to derive the energy savings. The PG&E report estimated savings for several climate zones. The climate zone (Amarillo, TX) was chosen to represent the entire state.[131] The deemed energy and demand savings are shown below.

Table 2-99: Modeled Deemed Savings for Night Covers for Texas (per Linear Foot)

Measure	Energy Savings [kWh/ft]	Demand Savings [kW/ft]
Night Covers on Vertical Low Temp Cases	45	0
Night Covers on Horizontal Low Temp Cases	23	0
Night Covers on Vertical Medium Temp Cases	35	0
Night Covers on Horizontal Medium Temp Cases	17	0

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 5 years in the DEER 2014 EUL update (EUL ID - GrocDisp-DispCvrs).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Display case type
- Refrigeration Temperature

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 provides energy and demand savings and measure specifications

Relevant Standards and Reference Sources

- DEER 2014 EUL update

[131] PUCT Docket No. 40669, page A-2 states that Amarillo, Texas was chosen as a conservative climate zone due to little variation between climate zones. This statement has not been expanded upon.

Document Revision History

Table 2-100: Nonresidential Night Covers for Open Refrigerated Display Cases History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Removed all references to Peak Demand Savings as this measure is implemented outside of the peak demand period. Also rounded off savings to a reasonable number of significant digits.

2.5.6 Solid and Glass Door Reach-Ins Measure Overview

TRM Measure ID: NR-RF-RI

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit & New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Algorithm

Measure Description

This document presents the deemed savings methodology for the installation of ENERGY STAR® or CEE certified Solid & Glass Reach-in doors for refrigerators and freezers, which are significantly more efficient. The high-efficiency criteria, developed by ENERGY STAR® and the Consortium for Energy Efficiency (CEE), relate the volume of the appliance to its daily energy consumption. These reach-in cases have better insulation and higher-efficiency than save energy, over regular refrigerators and freezers. The unit of measurement is volume in cubic feet of the unit. These four most common sized refrigerators and freezers are reported here.

Eligibility Criteria

Sold- or glass-door reach-in refrigerators and freezers must meet CEE or ENERGY STAR® minimum efficiency requirements (See Table 2-102).

Baseline Condition

Baseline efficiency case is a regular refrigerator or freezer with anti-sweat heaters on doors that meets federal standards. The baseline daily kWh for solid door and glass door commercial reach-in refrigerators and freezers are shown below in Table 2-101.

Table 2-101: Baseline Energy Consumption[132,133]

Baseline Standards	Refrigerator Daily Consumption [kWh]	Freezer Daily Consumption [kWh]
Solid Door	0.10V + 2.04	0.40V + 1.38
Glass Door	0.12V + 3.34	075V + 4.10

High-Efficiency Condition

Eligible high efficiency equipment for solid- or glass-door reach-in refrigerators and freezers must meet CEE or ENERGY STAR® minimum efficiency requirements, as shown in Table 2-102 below:

Table 2-102: Efficient Energy Consumption[134]

Efficiency Standards	Refrigerator Daily Consumption [kWh]	Freezer Daily Consumption [kWh]
Solid Door		
0 < V < 15	0.089V + 1.411	0.250V + 1.250
15 ≤ V < 30	0.037V + 2.200	0.400V – 1.000
30 ≤ V < 50	0.056V + 1.635	0.163V + 6.125
V ≥ 50	0.060V + 1.416	0.158V + 6.333
Glass Door		
0 < V < 15	0.118V + 1.382	0.607V + 0.893
15 ≤ V < 30	0.140V + 1.050	0.733V – 1.000
30 ≤ V < 50	0.088V + 2.625	0.250V + 13.500
V ≥ 50	0.110V + 1.500	0.450V + 3.500

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy and demand savings of Solid- and Glass-Door Reach-In Refrigerators and Freezers are calculated using values in Table 2-101 and Table 2-102, based on the volume of the units. The savings calculations are found below.

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132 The baseline energy consumption has been estimated by the Foodservice Technology Center (FSTC), based on data of energy consumption of baseline commercial refrigerators compiled by the California Energy Commission.

133 V = Interior volume [ft3] of a refrigerator or freezer (as defined in the Association of Home Appliance Manufacturers Standard HRF1-1979).

134 ENERGY STAR® Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency, Accessed on 7/7/10. http://www.energystar.gov/ia/partners/product_specs/program_reqs/commer_refrig_glass_prog_req.pdf

$$Energy\ [kWh] = (kWh_{base} - kWh_{ee}) \times 365$$

Equation 101

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{8760} \times CF$$

Equation 102

Where:

kWh_{base}	=	*Baseline maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 2-101.*
kWh_{ee}	=	*Efficient maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 2-102.*
V	=	*Chilled or frozen compartment volume [ft^3] (as defined in the Association of Home Appliance Manufacturers Standard HRF-1-1979)*
365	=	*Days per year*
8760	=	*Hours per year*
CF	=	*Summer Peak Coincidence Factor (1.0)*[135]

Deemed Energy and Demand Savings Tables.

N/A

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years, per the PUCT Texas EUL filing (Docket No. 36779). This is consistent with the 2008 DEER database[136].

Additional Calculators and Tools

N/A

[135] The Summer Peak Coincidence Factor is assumed equal to 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.
[136] DEER 2008, December 2008 Final Report.

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Baseline Unit Volume
- Baseline Unit Door Type (Solid or Glass)
- Baseline Unit Temperature (Refrigerator or Freezer)
- Post-Retrofit Unit Volume
- Post-Retrofit Unit Door Type (Solid or Glass)
- Post-Retrofit Unit Temperature (Refrigerator or Freezer)

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 provides energy and demand savings and measure specifications
- PUCT Docket 36779 provides EUL estimates for Commercial Refrigerators and Freezers

Relevant Standards and Reference Sources

- ENERGY STAR® Commercial Refrigerators & Freezers. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CRF. Accessed 08/20/2013
- Association of Home Appliance Manufacturers. HRF-1: Household Refrigerators, Combination Refrigerator-Freezers, and Household Freezers

Document Revision History

Table 2-103: Nonresidential Solid and Glass Door Refrigerators and Freezers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.5.7 Strip Curtains for Walk-In Refrigerated Storage Measure Overview

TRM Measure ID: NR-RF-SC

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit & New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Value (per door/opening)

Savings Methodology: M&V analysis

<u>Measure Description</u>

This measure refers to the installation of infiltration barriers (strip curtains or plastic swinging doors) on walk-in coolers or freezers. These units impede heat transfer from adjacent warm and humid spaces into walk-ins when the main door is opened, reducing the cooling load. This results in a reduced compressor run-time, reducing energy consumption. This assumes that a walk-in door is open 2.5 hours per day every day, and strip curtains cover the entire door frame.

Eligibility Criteria

Strip curtains or plastic swinging doors installed on walk-in coolers or freezers.

Baseline Condition

Baseline efficiency case is a refrigerated walk-in space with nothing to impede air flow from the refrigerated space to adjacent warm and humid space when the door is opened.

High-Efficiency Condition

Eligible high efficiency equipment in a polyethylene strip curtain added to the walk-in cooler or freezer. Any suitable material sold as a strip cover for a walk-in unit is eligible as long as it covers the entire doorway.

<u>Energy and Demand Savings Methodology</u>

Savings Algorithms and Input Variables

Savings are derived from an M&V study.

Deemed Energy and Demand Savings Tables

The energy and demand savings for strip curtains are based on the assumption that the walk-in door is open 2.5 hours per day, every day, and the strip curtain covers the entire door frame, and are shown below in Table 2-104.

Table 2-104: Deemed Energy and Demand Savings for Freezers and Coolers[137]

Savings	Coolers	Freezers
Energy [kWh]	422	2,974
Demand [kW]	0.05	0.35

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 4 years, per the PUCT Texas EUL filing (Docket No. 36779) and by the DEER 2014 EUL update (EUL ID - GrocWlkIn-StripCrtn).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Unit Temperature (Refrigerator or Freezer)

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 provides energy and demand savings and measure specifications
- PUCT Docket 36779 provides EUL estimates for Commercial Refrigerators and Freezers

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 2-105: Nonresidential Walk-In Refrigerator and Freezer Strip Curtains History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

[137] Values based on analysis prepared by ADM for FirstEnergy utilities in Pennsylvania, provided by FirstEnergy on June 4th, 2010. Based on a review of deemed savings assumptions and methodologies from Oregon and California.

2.5.8 Zero Energy Doors for Refrigerated Cases Measure Overview

TRM Measure ID: NR-RF-ZE

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Any commercial retail facility such as supermarkets, grocery stores, hotels, restaurants and convenience stores

Fuels Affected: Electricity

Decision/Action Type: Retrofit or New Construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Values

Savings Methodology: Engineering estimates

Measure Description

This document presents the deemed savings methodology for the installation of Zero Energy Doors for refrigerated cases. These new zero-energy door designs 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.

Eligibility Criteria

This measure cannot be used in conjunction with anti-sweat heat (ASH) controls. It is not eligible to be installed on cases above 0ºF.

Baseline Condition

Baseline efficiency case is a standard vertical reach-in refrigerated case with anti-sweat heaters on the glass surface of the doors.

High-Efficiency Condition

Eligible high efficiency equipment is the installation of special doors that eliminate the need for anti-sweat heaters, for low-temperature cases only (below 0 ºF). Doors must have either heat reflective treated glass, be gas-filled, or both.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy and demand savings from the installation of zero-energy doors are listed below:

$$Energy\ [kWh] = \Delta kW \times 8760$$

Equation 103

$$Peak\ Demand\ [kW] = kW_{door} \times BF$$

‘

Equation 104

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	=	*Hours per year*

Table 2-106: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
kW_{door}[138]	Cooler: 0.075 Freezer: 0.200
BF[139]	Low-Temp Freezer: 1.3 Medium-Temp Freezer: 1.2 High-Temp Freezer: 1.1

Deemed Energy and Demand Savings Tables

The energy and demand savings of zero-energy doors are listed below in Table 2-107.

[138] 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.

[139] 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 discus 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.

Table 2-107: Energy and Demand Deemed Savings[140]

Technology Type	Energy Savings [kWh]	Peak Demand Savings [kW]
Low-Temperature Freezer	2,278	0.26
Medium-Temperature Cooler	788	0.09
High-Temperature Cooler	723	0.08

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years per the PUCT approved Texas EUL filing (Docket No. 36779) and the DEER 2014 EUL update (EUL ID – GrocDisp-ZeroHtDrs).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Refrigeration Temperature Range

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 provides energy and demand savings and measure specifications
- PUCT Docket 36779 provides EUL values for Zero Energy Doors.

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 2-108: Nonresidential Zero-Energy Refrigerated Case Doors History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

140 PUCT Docket 40669 states that energy savings credit for these doors applies only to low temperature cases (< 0ºF), yet it also provides savings for medium-temperature and high-temperature cases.

2.6 NONRESIDENTIAL: MISCELLANEOUS

2.6.1 Vending Machine Controls Measure Overview

TRM Measure ID: NR-MS-VC

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: All building types applicable

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Value (per machine)

Savings Methodology: M&V

Measure Description

This section presents the deemed savings methodology for the installation of Vending Machine controls to reduce energy usage during periods of inactivity. These controls reduce energy usage by powering down the refrigeration and lighting systems when the control device signals that there is no human activity near the machine. If no activity or sale is detected over the manufacturer's programmed time duration, the device safely de-energizes the compressor, condenser fan, evaporator fan, and any lighting. For refrigerated machines, it will power up occasionally to maintain cooling to meet the machine's thermostat set point. When activity is detected, the system returns to full power. The energy and demand savings are determined on a per-vending machine basis.

Eligibility Criteria

N/A

Baseline Condition

Eligible baseline equipment is a 120 volt single phase vending machine manufactured and purchased prior to August 31, 2012.

High-Efficiency Condition

Eligible equipment is a refrigerated vending machine or non-refrigerated snack machine (including warm beverage machines) without any controls. It is assumed that the display lighting has not been permanently disabled.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

N/A

Deemed Energy and Demand Savings Tables

Energy and demand savings are deemed values for different sized vending machines. These values have been pieced together from different sources and studies. The energy and demand savings of Vending Machine Controllers are deemed values. The following tables provide these deemed values.

Table 2-109: Deemed Energy and Demand Savings Values by Equipment Type

Size	Annual Energy Savings [kWh]	Peak Demand Savings [kW][141]
Control for Refrigerated Cold Drink Unit cans or bottles	1,612[142]	0.030
Control for Refrigerated Reach-in Unit any sealed beverage	1,086[143]	0.035
Control for Non-Refrigerated Snack Unit with lighting (include. Warm beverage)	387[144]	0.006

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 5 years per the PUCT approved Texas EUL filing (Docket No. 36779) and the DEER 2014 EUL update (EUL ID – Plug-VendCtrler).

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Vending Machine Type
- Refrigerated Cold Drink Unit, Refrigerated Reach-in Unit, or Non-Refrigerated Snack Unit with lighting

[141] Chappell, C., Hanzawi, E., Bos, W., Brost, M., and Peet, R. (2002). "Does It Keep the Drinks Cold and Reduce Peak Demand? An Evaluation of a Vending Machine Control Program," 2002 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings, pp. 10.47-10.56.
[142] Pacific Gas and Electric, Work Paper VMCold, Revision 3, August, 2009, Measure Code R97.
[143] Pacific Gas and Electric, Work Paper VMReach, Revision 3, August, 2009, Measure Code R143.
[144] Pacific Gas and Electric, Work Paper VMSnack, Revision 3, August, 2009, Measure Code R98.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 – Provides energy and demand savings and measure specifications. Appendix A: http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/40669_3_735684.PDF. Accessed 9/24/2013.
- PUCT Docket 36779 – Provides EUL for Vending Machine Controls

Relevant Standards and Reference Sources

- Chappell, C., Hanzawi, E., Bos, W., Brost, M., and Peet, R. (2002). "Does It Keep the Drinks Cold and Reduce Peak Demand? An Evaluation of a Vending Machine Control Program," 2002 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings, pp. 10.47-10.56. http://www.eceee.org/library/conference_proceedings/ACEEE_buildings/2002/Panel_10/p10_5/paper. Accessed 9/24/2013.
- DEER 2014 EUL update

Document Revision History

Table 2-110: Nonresidential Vending Machine Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.6.2 Lodging Guest Room Occupancy Sensor Controls Measure Overview

TRM Measure ID: NR-MS-GR

Market Sector: Commercial

Measure Category: HVAC, Indoor Lighting

Applicable Building Types: Hotel/Motel Guestrooms, Schools/Colleges (Dormitory)

Fuels Affected: Electricity

Decision/Action Type: Retrofit (RET)

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Building Simulation

Measure Description

This measure captures the potential energy and demand savings resulting from occupancy sensor control of HVAC and lighting in unoccupied hotel/motel guest rooms. Hotel and motel guest room occupancy schedules are highly variable, and guests often leave HVAC equipment and lighting on when they leave the room. Installation of occupancy controls can reduce the unnecessary energy consumption in unoccupied guest rooms. Savings have also been developed for use of this measure in college dormitories.[145] This measure is also commonly referred to as a guest room energy management (GREM) system.

Eligibility Criteria

To be eligible for HVAC savings, controls must be capable of either a 5ºF or 10ºF temperature offset. To be eligible for lighting savings, at least 50% of all the lighting fixtures in a guest room – both hardwired and plug-load lighting - must be actively controlled.

Baseline Condition

The baseline condition is a guest room or dorm room without occupancy controls.

[145] The original petition also includes savings for HVAC-only control in master-metered multifamily individual dwelling units. These values are not reported here because the permanent occupation of a residential unit is quite different from the transitory occupation of hotel/motels, and even dormitories. This measure is not currently being implemented and is not likely to be used in the future, but it can be added to a future TRM if warranted.

High-Efficiency Condition

The high-efficiency condition is a hotel/motel guest room or dorm room with occupancy controls. The occupancy sensors can control either the HVAC equipment only, or the HVAC equipment and the interior lighting (including plug-in lighting).

The occupancy-based control system must include, but not be limited to, infrared sensors, ultrasonic sensors, door magnetic strip sensors, and/or card-key sensors. The controls must be able to either completely shut-off the HVAC equipment serving the space and/or place it into an unoccupied temperature setback/setup mode.

Energy and Demand Savings Methodology

Energy and demand savings are deemed values based on energy simulation runs performed using EnergyPro Version 5. Building prototype models were developed for a hotel, motel, and dormitory. The base case for each prototype model assumed a uniform temperature setting, and was calibrated to a baseline energy use. Occupancy patterns based on both documented field studies[146] and prototypical ASHRAE 90.1-1999 occupancy schedules were used in the energy simulation runs to create realistic vacancy schedules. The prototype models were then adjusted to simulate an occupancy control system, which was compared to the baseline models.[147]

Savings Algorithms and Inputs

A building simulation approach was used to produce savings estimates.

Deemed Energy and Demand Savings Tables

Energy and demand savings are provided by region, for HVAC-Only and HVAC+Lighting control configurations, and for three facility types: Motel and Hotel guest rooms, and Dormitory rooms.

[146] HVAC occupancy rates appear to be based on a single HVAC study of three hotels, but not dorms or multifamily buildings. For the lighting study, a typical guest room layout was used as the basis for the savings analysis. Hotel guest rooms are quite different from either dorms or multifamily units.

[147] A more detailed description of the modeling assumptions can be found in Docket 40668 Attachment A, pages A-46 through A-58.

Table 2-111: Deemed Energy and Demand Savings for Motel per Guest Room, by Region

Representative City (Region)[148]	Heat Pump				Electric Heat			
	HVAC-Only		HVAC & Lighting		HVAC-Only		HVAC & Lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
5-Degree Setup/Setback Offset								
Amarillo (Panhandle)	0.059	267	0.075	380	0.059	341	0.075	441
Dallas-Ft Worth (North)	0.076	315	0.091	443	0.076	365	0.091	485
Houston (South)	0.082	324	0.097	461	0.082	351	0.097	484
McAllen (Valley)	0.086	354	0.103	500	0.086	369	0.103	513
El Paso (West)	0.063	251	0.078	379	0.063	283	0.078	406
10-Degree Setup/Setback Offset								
Amarillo (Panhandle)	0.111	486	0.126	598	0.111	627	0.126	726
Dallas-Ft Worth (North)	0.146	559	0.161	686	0.146	640	0.161	761
Houston (South)	0.151	559	0.166	695	0.151	602	0.166	735
McAllen (Valley)	0.163	617	0.179	761	0.163	650	0.179	792
El Paso (West)	0.118	432	0.133	561	0.118	482	0.133	607

Table 2-112: Deemed Energy and Demand Savings for Hotel per Guest Room, by Region

Representative City (Region)	Heat Pump				Electric Heat			
	HVAC-Only		HVAC & Lighting		HVAC-Only		HVAC & Lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
5-Degree Setup/Setback Offset								
Amarillo (Panhandle)	0.053	232	0.072	439	0.053	303	0.072	530
Dallas-Ft Worth (North)	0.073	258	0.093	452	0.073	303	0.093	505
Houston (South)	0.074	242	0.094	430	0.074	260	0.094	450
McAllen (Valley)	0.081	260	0.102	451	0.081	267	0.102	459
El Paso (West)	0.056	178	0.075	360	0.056	196	0.075	380
10-Degree Setup/Setback Offset								
Amarillo (Panhandle)	0.102	426	0.121	568	0.102	557	0.121	684
Dallas-Ft Worth (North)	0.134	452	0.154	617	0.134	517	0.154	676
Houston (South)	0.136	423	0.156	599	0.136	446	0.156	621
McAllen (Valley)	0.149	467	0.169	652	0.149	483	0.169	667
El Paso (West)	0.106	312	0.126	479	0.106	338	0.126	501

[148] Regions used in the original petition were mapped to current TRM representative weather stations and regions as follows: Amarillo (Panhandle) was "Panhandle", Dallas-Ft Worth (North) was "North", Houston (South) was "South Central", El Paso (West) was "Big Bend", and McAllen (Valley) was "Rio Grande Valley".

Table 2-113: Deemed Energy and Demand Savings for Dormitories per Room, by Region

Representative City (Region)	Heat Pump				Electric Heat			
	HVAC-Only		HVAC & Lighting		HVAC-Only		HVAC & Lighting	
	kW	kWh	kW	kWh	kW	kwh	kW	kWh
5-Degree Setup/Setback Offset								
Amarillo (Panhandle)	0.034	136	0.061	319	0.034	152	0.061	316
Dallas-Ft Worth (North)	0.048	214	0.076	425	0.048	223	0.076	428
Houston (South)	0.051	242	0.078	461	0.051	244	0.078	462
McAllen (Valley)	0.053	265	0.081	492	0.053	266	0.081	492
El Paso (West)	0.031	110	0.059	327	0.031	110	0.059	326
10-Degree Setup/Setback Offset								
Amarillo (Panhandle)	0.073	261	0.084	404	0.073	289	0.084	417
Dallas-Ft Worth (North)	0.078	293	0.105	505	0.078	304	0.105	511
Houston (South)	0.081	326	0.108	543	0.081	328	0.108	545
McAllen (Valley)	0.088	368	0.114	591	0.088	370	0.114	593
El Paso (West)	0.045	151	0.060	448	0.045	153	0.060	450

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

Estimated Useful Life is 10 years based on the value for retrofit energy management system (EMS) HVAC control from the Massachusetts Joint Utility Measure Life Study[149]. This value is also consistent with the EUL for lighting control and HVAC control measures in PUCT Docket Nos. 36779 and 40668.

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- HVAC System and Equipment Type
- Climate Zone/Region
- Temperature Offset category (5 or 10 degrees)

[149] Energy & Resource Solutions (2005). *Measure Life Study.* Prepared for the Massachusetts Joint Utilities; Table 1-1, Prescriptive Common Measure Life Recommendations, Large C&I Retrofit, HVAC Controls, EMS.

- Control Type (HVAC-Only or HVAC & Lighting)
- Business/Room Type
- Number of Rooms

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40668 – Provides deemed energy and demand savings values under "Guestroom, Dormitory and Multi-family Occupancy Controls for HVAC and Lighting Systems", page 25 and Attachment pages A-46 through A-58.
- PUCT Docket 36779 – Provides EULs for commercial measures.

Relevant Standards and Reference Sources

- ASHRAE Standard 90.1-1999
- Measure Life Study. Prepared for The Massachusetts Joint Utilities by ERS. November 17, 2005.
- Codes and Standards Enhancement Initiative (CASE): Guest Room Occupancy Controls, 2013 California Building Energy Efficiency Standards. October 2011.

Document Revision History

Table 2-114: Lodging Guest Room Occupancy Controls History

TRM Version	Date	Description of Change
v2.0	04/18/2014	TRM V2.0 origin

2.6.3 Pump-off Controller Measure Overview

TRM Measure ID: NR-MS-PC

Market Sector: Commercial

Measure Category: Controls

Applicable Building Types: Industrial

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Algorithm

Savings Methodology: Engineering estimates, Field study, Algorithm

Measure Description

Pump-off Controllers (POC) are micro-processor-based devices that continuously monitor pump down conditions, which is the condition when the fluid in the well bore is insufficient to warrant continued pumping. These controllers are used to shut down the pump when the fluid falls below a certain level and "fluid pounding[150]" occurs. POCs save energy by optimizing the pump run-times to match the flow conditions of the well.

Eligibility Criteria

The POC measure retrofit is available for existing wells (wells with an existing API number[151] prior to September 11th, 2014) with rod pumps using 15 hp or larger motors operating on time clock controls or less efficient devices. These cannot be integrated with a variable frequency drive, and only apply to POCs using load cells, which measure the weight on the rod string for greater precision. Additionally, the POC must control a *conventional* well (above ground, vertical, with a standard induction motor of 480V or less).

Baseline Condition

The baseline condition is an existing conventional well (with an API number prior to September 11th, 2014) with rod pumps operating on time clock controls or less efficient control devices.

High-Efficiency Condition

The efficient condition is the same existing well retrofitted with a pump-off controller.

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150 Fluid pounding occurs when the downhole pump rate exceeds the production rate of the formation. The pump strikes the top of the fluid column on the downstroke causing extreme shock loading of the components which can result in premature equipment failure.

151 The API number is a unique, permanent identifier assigned by the American Petroleum Institute. The API number should correspond to a well that was in existence prior to the date of PUCT Docket 42551.

Energy and Demand Savings Methodology

Two main sources were referenced to develop the savings methods for the POC measure: *Electrical Savings in Oil Production*[152] (SPE 16363), which identified a relationship between volumetric efficiency and pump run times, and the *2006-2008 Evaluation Report for PG&E Fabrication, Process, and Manufacturing Contract Group*[153], which showed a reduction in savings from the SPE 16363 paper. These two methods were the basis of the current savings calculations and deemed inputs listed below. However, to develop Texas-specific stipulated values, field and metering data will be collected in 2015 and used to calibrate and update the savings calculation methods and input variables for a future version of the TRM[154].

Savings Algorithms and Inputs

The energy and demand algorithms and associated input variables are listed below:

$$Energy\ Savings\ [kWh] = kW_{avg} * (TimeClock\%On - POC\%On) * 8760$$

Equation 105

$$Demand\ Savings\ [kW] = \frac{EnergySavings}{8760}$$

Equation 106[155]

The inputs for the energy and peak coincident demand savings are listed below:

$$kW_{avg} = HP \times 0.746 \times \frac{\frac{LF}{ME}}{SME}$$

Equation 107

$$POC\%On = \frac{Run_{Constant} + Run_{Coefficient} \times VolumetricEfficiency\% \times TimeClock\%On \times 100}{100}$$

Equation 108[156]

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[152] Bullock, J.E. "SPE 16363 *Electrical Savings in Oil Production",* (paper presented at the Society of Petroleum Engineers California Regional Meeting held in Ventura, California, April 8-10, 1987).

[153] *2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group.* Calmac Study ID: CPU0017.01. Itron, Inc. Submitted to California Public Utilities Commission. February 3, 2010.

[154] The EM&V Team will work with SPS/Xcel Energy in developing the sample plan for the field data collection effort.

[155] The equations in the petition for peak demand simplify to the equation shown.

[156] This equation from the petition deviates from that in SPE 16363 but will provide conservative savings estimates. The equation will be updated and made consistent when this measure is updated with field data. The correct equation term is ($Run_{contstant}$ + $Run_{coefficient}$ * VolumetricEfficiency%) with the volumetric efficiency expressed as percent value not a fraction (i.e. 25 not 0.25 for 25%).

Where:

kW_{avg}	=	*The demand used by each rod pump*
HP	=	*Rated pump motor horsepower*
0.746	=	*Conversion factor from HP to kW*
LF	=	*Motor load factor – ratio of average demand to maximum demand, see Table 2-115*
ME	=	*Motor efficiency, based on NEMA Standard Efficiency Motor, see Table 2-116*
SME	=	*Mechanical efficiency of sucker rod pump, see Table 2-115*
TimeClock%On	=	*Stipulated baseline timeclock setting, see Table* 2-115
$Run_{constant,}$ $Run_{coefficient}$	=	*8.336, 0.956. Derived from SPE 16363*[157]
VolumetricEfficiency%	=	*Average well gross production divided by theoretical production (provided on rebate application)*

[157] Bullock, J.E. "SPE 16363 *Electrical Savings in Oil Production",* (paper presented at the Society of Petroleum Engineers California Regional Meeting held in Ventura, California, April 8-10, 1987).

Deemed Energy and Demand Savings Tables

Table 2-115: Deemed Variables for Energy and Demand Savings Calculations

Variable	Stipulated/Deemed Values
LF (Load Factor)	25%[158]
ME (motor efficiency)	See Table 2-116
SME (pump mechanical efficiency)	95%[159]
Timeclock%On	65%[160]

Table 2-116: NEMA Premium Efficiency Motor Efficiencies[161]

Motor Horsepower	Nominal Full Load Efficiency					
	Open Motors (ODP)			Enclosed Motors (TEFC)		
	6 poles	4 poles	2 poles	6 poles	4 poles	2 poles
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
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%	93.6%
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%

Claimed Peak Demand Savings

Because the operation of the POC coincident with the peak demand period is uncertain, a simple average of the total savings over the full year (8760 hours) is used, as shown in Equation 106 above.

[158] *Comprehensive Process and Impact Evaluation of the (Xcel Energy) Colorado Motor and Drive Efficiency Program, FINAL*. TetraTech. March 28, 2011. Adjusted based on Field Measurements provided by ADM Associates, based on 2010 custom projects.

[159] Engineering estimate for standard gearbox efficiency.

[160] A TimeClock%On of 80% is typical from observations in other jurisdictions, but that was adjusted to 65% for a conservative estimate. This value will be reevaluated once Texas field data is available.

[161] DOE Final Rule regarding energy conservation standards for electric motors. 79 FR 30933. Full-Load Efficiencies for General Purpose Electric Motors [Subtype I] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/50.

Measure Life and Lifetime Savings

The EUL for this measure is 15 years[162].

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Motor Make
- Motor Model Number
- Rated Motor Horsepower
- Motor Type (TEFC or ODP)
- Rated Motor RPM
- Baseline control type and timeclock % on time (or actual on-time schedule)
- Volumetric Efficiency
- Field data on actual energy use and post-run times[163]

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 42551 – Provides energy and demand savings calculations and EUL

Relevant Standards and Reference Sources

- Bullock, J.E. "SPE 16363 Electrical Savings in Oil Production", (paper presented at the Society of Petroleum Engineers California Regional Meeting held in Ventura, California, April 8-10, 1987).
- 79 FR 30933. Full-Load Efficiencies for General Purpose Electric Motors [Subtype I]

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[162] CPUC 2006-2008 Industrial Impact Evaluation "SCIA_06-08_Final_Report_Appendix_D-5": An EUL of 15 years was used for the ex-post savings, consistent with the SPC – Custom Measures and System Controls categories in the CPUC Energy Efficiency Policy Manual (Version 2) and with DEER values for an energy management control system.

[163] Per PUCT Docket 42551, Southwestern Public Service Company (SPS)/Xcel Energy has agreed to collect field data in 2015 on post-run times for a sample of wells in order to improve the accuracy of POC saving estimates.

- 2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group. Calmac Study ID: CPU0017.01. Itron, Inc. Submitted to California Public Utilities Commission. February 3, 2010.
- Comprehensive Process and Impact Evaluation of the (Xcel Energy) Colorado Motor and Drive Efficiency Program, FINAL. TetraTech. March 28, 2011.

Document Revision History

Table 2-117: Pump-off Controller History

TRM Version	Date	Description of Change
v2.1	01/30/2015	TRM v2.1 origin

2.7 NONRESIDENTIAL: RENEWABLES

2.7.1 Solar Photovoltaic (PV) Measure Overview

TRM Measure ID: NR-RN-PV

Market Sector: Commercial

Measure Category: Renewables

Applicable Building Types: All

Fuels Affected: Electricity

Decision/Action Type: N/A

Program Delivery Type: Prescriptive Rebate

Deemed Savings Type: Deemed Savings Values and Calculation

Savings Methodology: Algorithms, Model-Calculator (PVWatts™)

Measure Description

This section summarizes the savings calculations of the Solar Photovoltaic Standard Offer, Market Transformation, and Pilot programs. These programs are offered by the Texas utilities, with the primary objective to achieve cost-effective energy savings and peak demand savings. Participation in the Solar Photovoltaic program involves the installation of a solar photovoltaic system. There are two primary methods used to estimate savings. The deemed method uses deemed algorithms, and the M&V method uses a simulation tool: the National Renewable Energy Laboratory's (NREL) PVWatts™. Each utility has a minimum and maximum incentivized system size, as shown in Table 2-118, as well as additional eligibility criteria.

Table 2-118: Incentivized System Ranges by Utility

Utility	Minimum Incentivized Size [kW][164]	Maximum Incentivized Size [kW]
Oncor	1 kW	N/A
AEP (all entities)	1 kW	25 kW
El Paso Electric (EPE)	1 kW	50 kW

Eligibility Criteria

A project will be eligible for rebates under the Solar Photovoltaic programs if the following criteria are met:

- Eligible equipment must be new, and used for individually metered commercial buildings. Used, refurbished, and existing solar PV systems are not eligible for incentives.

[164] Minimum size of 1kW may be waived for AEP and EPE in the event that the system is designed for educational use in schools.

- System ranges must be met, as described above in Table 2-118.
- Solar electric systems must deliver energy to a building's electrical distribution system which is connected to the utility. Portable systems, systems of a temporary nature, and off-grid systems are ineligible.

Each utility may have additional program eligibility requirements, which are listed here. These requirements are provided for reference purposes only, and are not listed in any PUCT-approved petition. Therefore, these utility-specific eligibility requirements may be subject to change.

Oncor:

- Electrical output of the installed solar PV system is limited to 75% of the host customer's demand during summer peak demand. Additionally, annual energy generation should not exceed the customer's annual energy consumption.[165]
- A deemed savings approach can only be used for "standard" systems. A standard system, for both residential and nonresidential PV systems, is defined as a system that does not exceed an azimuth angle of +/- 20º of south, and has a tilt angle between 0º (horizontal) and [system latitude + 15º]. The azimuth angle requirement is irrelevant for flat panel systems. Systems that fall outside of these requirements are considered non-standard systems, and are required to use a site-specific approach for energy and demand production impacts.

El Paso Electric & AEP[166]:

- Modules and Inverters must be new and certified to UL 1741 standards by a Nationally Recognized Testing Laboratory (NRTL). Eligible modules must be warranted for at least 10 years to produce at least 90% of their rated power output, and for at least 20 years to produce at least 80% of their rated power output.
- Energy produced will be monitored by a utility-provided Revenue-Grade Solar (REC) Meter.
- The estimated annual electrical energy output of a solar electric system, as modeled by National Renewable Energy Laboratory's (NREL) PVWatts™[167] and considering an appropriate factor for shading, must be at least 80% of the estimated annual energy output for an optimally-sited,[168] un-shaded system of the same DC capacity.
- A deemed savings approach is used to claim savings for all eligible systems, however, no mention of this deemed savings approach is found in any of the EPE or AEP program manuals. The deemed savings approach used is the same as is used by

[165] This criteria is stated in the 2013 Oncor Technical Resource Manual for Solar Electric (Photovoltaic) Energy Systems.

[166] Additional requirements on mounting systems, AC disconnects, and systems with integrated battery backup can be found in the program manuals.

[167] PVWatts™. A Performance Calculator for Grid-Connected PV Systems. National Renewable Energy Laboratory (NREL). http://rredc.nrel.gov/solar/calculators/pvwatts/version1/. Accessed 09/09/2013.

[168] Optimally-sited system is determined by selecting an appropriate location, entering system capacity in kWdc, and accepting default parameters for tilt (latitude tilt), orientation (due south), and derating factor (0.77) into the PVWatts calculator.

Oncor, and listed below in the section on Savings Algorithms and Input Variables. The EPE and AEP program manuals actually discuss the method of savings calculations as an M&V Methodology, however, project desk reviews performed for the 2012 evaluations did not find any of these M&V methods being used. The M&V methodology, which is currently being used by Oncor for non-standard installations, is listed below in the section titled, M&V Methodology.

Baseline Condition

PV system not currently installed (typical), or production capacity of an existing system is less than any utility requirements, so that additional panels can be added.

High-Efficiency Condition

PV systems must meet the eligibility criteria shown above to be eligible for incentives.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The deemed energy and demand savings methodology is used by all utilities. An alternate approach for 'non-standard' installations is also available state-wide.

Energy and demand savings methodology for standard installations use a deemed algorithm based on the system size.

$$\boldsymbol{Deemed\ Energy\ Savings\ [kWh] = 1.6 \times WattsDC_{STC}}$$

Equation 109

$$\boldsymbol{Deemed\ Demand\ Savings\ [kW] = 0.83 \times kWDC_{STC}}$$

Equation 110

Where:

1.6	=	*Energy factor*[169]
0.83	=	*Demand factor* [169]
WattsDCSTC	=	*The system's factory-rated output at standard test conditions (STC), which assumes 1,000 W/m^2 of solar radiation and 25ºC cell operating temperature*

For non-standard installations, the method of calculating savings is the same, based on the deemed savings methodology; however, additional information has to be collected to ensure that these projects are still eligible to be incentivized. See the section labeled *Program Tracking*

[169] The source of this value is not defined in any petition. The value is believed to be derived from analysis of a single site in the Abilene area, which was deemed to be representative for the entire state due to its somewhat central location.

Data & Evaluation Requirements below to see the additional information needing to be collected.

M&V Methodology[170]

The estimated annual electrical energy output of the proposed system shall be derived from PVWatts™ and shall consider separately the effects of tilt, orientation and shading on each array and/or string, as appropriate. The effect of shading shall be determined using a Solar Pathfinder or equivalent instrument. As a general rule, multiple shading measurements should be made along the lower or southern edge of an array, and/or locations where shading is most prevalent.

Non-Standard Installation:

PUCT Docket No. 40885 allows for alternative means for estimating deemed savings for solar PV systems for non-standard installations, allowing commercial customers around the state access to utility incentives for systems installed on roofs – or portions of roofs – that are not within 20 degrees of south, or for which the tilt angle must exceed 15 degrees from horizontal due to site specific considerations. The proposed alternative would also facilitate the installation of single-axis or two-axis tracking systems.

For those solar PV installations that do not conform to the installation standards of the existing deemed savings, the deemed demand and energy savings be established by modeling the performance of the system using PVWatts™ Version1.

Claimed Peak Demand Savings

Refer to Volume 1, Appendix B: Peak Demand Reduction Documentation for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The Effective Useful Life (EUL) for solar PV has been set at 30 years, based on PUCT Docket No. 36779.

Additional Calculators and Tools

Oncor's Solar PV Savings Summary Sheet Using PV Watts. This calculator provides deemed savings estimates for standard-installation PV systems. For non-standard installation PV systems, the results from PVWatts™ or from M&V should be input into the calculator.

Program Tracking Data & Evaluation Requirements

The following information will be required to be collected to determine the project eligibility.

[170] Desk reviews of solar PV projects for PY2012 in EPE and AEP found no record that this approach is being used.

- Project location (city)
- DC rating for the system
- Standard or Non-Standard System
- Savings approach type: Deemed algorithm or PVWatts™
- System Latitude
- System Tilt
- System Azimuth

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40885 – Allows for alternative means for estimating deemed savings for solar PV systems is proposed for unconventional installations, allowing commercial customers around the state access to utility incentives for systems installed on roofs – or portions of roofs – that are not within 20 degrees of south, or for which the tilt angle must exceed 15 degrees from horizontal due to site specific considerations. The proposed alternative would also facilitate the installation of single-axis or two-axis tracking systems.
- PUCT Docket 36779 – Provides estimate for EUL.

Relevant Standards and Reference Sources

- El Paso Electric Solar PV Pilot Program Guidebook. Program Year 2013. http://www.txreincentives.com/elpasopv/documents/El%20Paso%20Electric%202013%20Program%20Guidebook%2020130118.pdf. Accessed 09/09/2013.
- AEP. SMART Source Solar PV Program Guidebook. Program Year 2013. http://www.txreincentives.com/apv/documents/AEP-TCC%20AEP-TNC%20SWEPCO%20PV%20Program%20Guidebook%202013%2020130204.pdf. Accessed 09/09/2013.
- Oncor. Solar Photovoltaic Standard Offer Program. https://www.oncoreepm.com/SolarPV.aspx. Accessed 09/09/2013.

Document Revision History

Table 2-119: Nonresidential Solar Photovoltaic History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin

2.8 NONRESIDENTIAL: LOAD MANAGEMENT

2.8.1 Load Curtailment Measure Overview

TRM Measure ID: NR-LM-LC

Market Sector: Commercial

Measure Category: Load Management

Applicable Building Types: Any building that meets Minimum facility demand requirements (see Table 2-120)

Fuels Affected: Electricity

Decision/Action Type: N/A

Program Delivery Type: Load Control

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: M&V

Measure Description

This document presents the deemed savings methodology for participation in a load management program that involves the curtailment of an interruptible load during the summer peak period. Project sponsors, who have agreed to deliver demand savings to the utility from the utility's customer, must commit to an availability of curtailed load throughout the Summer Peak Demand Period. These project sponsors may include national or local energy efficiency service providers (EESPs), retail electricity providers (REPs) or individual customers. Different utilities offer different details on their programs, but they all have similar eligibility criteria, listed below:

Eligibility Criteria

A project will be eligible for rebates under the Load Management SOP program if the following criteria are met:

- Each meter included in a project must include a total potential demand savings of a specified minimum kW (varies by utility, as seen in Table 2-120) during the summer peak period as defined in Table 2-121.

Table 2-120: Minimum Facility Demand Savings by Utility

Utility	Minimum Demand Savings [kW]
Oncor	100
TNMP	50[171]
AEP (TNC, TCC & SWEPCO)	50
Xcel	100[172]
CenterPoint	100
Sharyland	100
Entergy	250
El Paso Electric	100

Table 2-121: Peak Demand Period by Utility

Utility	Hours	Months	Exceptions
Oncor, AEP, TNMP, CenterPoint, Sharyland, Entergy, El Paso Electric	1PM – 7PM	June, July, August, September	Weekends, Federal Holidays
Xcel	12PM – 8PM[173]	June, July, August, September	Weekends, Federal Holidays

- A single project may involve identifying curtailable load at more than one customer facility, provided the curtailment demand savings at the facilities are reported using a single Interval Data Recorder (IDR).
- The project sponsor agrees to verify that the curtailable load that is being used in its application will not be used and counted in any other curtailable load or demand response program during the duration of the customer contract. The project sponsor will notify the Utility Company within 15 business days of any change in the status of the curtailable load or its inclusion in another demand response program.
- Curtailable load must produce demand savings through a curtailment of electrical consumption during the performance period.
- Project sponsors must commit to making the curtailable load available during the summer peak period for the program.

[171] TNMP prefers that project sponsors be capable of providing at least 50 kW of peak demand reduction at each site for which load reduction is offered; however, TNMP may accept applications including sites providing less than 50kW of peak demand reduction in the interest of meeting its peak load reduction targets.

[172] The utility prefers that project sponsors be capable of providing at least 100kW of peak demand reduction at each site for which load reduction is offered; however, the utility may accept applications including sites providing less than 100kW of peak demand reduction in the interest of meeting its peak load reduction targets.

[173] Note that although Xcel starts and ends events outside the 1 pm to 7 pm period, Xcel only claims savings for deliveries during the rule-defined 1-7 pm peak period.

- Be served by an Interval Data Recorder (IDR) and/or smart meter that is monitored by the utility.
- Customer agrees to respond to at least one event (scheduled or unscheduled) per year for the purpose of verifying the load reduction is available for potential calls. Scheduled events are used to provide an estimate of the load reduction in the event that no unscheduled interruptions occur during the season.

The following loads are excluded for consideration:

- A customer who has load contracted with a REP where that contract prevents the load from participating in a curtailment.
- Loads where curtailment would result in negative environmental or health effects.
- Curtailable load that receives an incentive through any other energy efficiency program.
- Curtailable load that takes electric service at transmission voltage and that serves a for-profit end-use customer.

Baseline Condition

Standard facility operation.

High-Efficiency Condition

Requires Load Management customers to participate in a certain number of unscheduled interruptions. Programs will provide a minimum of 30-minute advanced notice, allowing facility managers sufficient time to use non-automated approaches. Another option is for facilities to install a load-control device on specific end-uses, equipment, or circuit loads.

Additional Utility Program Details

Each utility in Texas provides slightly different guidelines for their load management program. These details differ in the length of the unscheduled interruptions (also called curtailments), the maximum number or maximum number of hours of unscheduled interruptions, and the length of notification provided to the project sponsor. Table 2-122 below highlights these differences.

Each utility states that participants will be willing to participate in a maximum number of unscheduled interruptions, or a maximum number of scheduled (test) interruption hours. In addition to these, all utilities require that a scheduled interruption be performed. The purpose of this is to ensure that the project sponsor will be able to curtail the requested kW within the required notification time and to provide an estimate of the load reduction in the event that no unscheduled interruptions occur during the season. Additionally, some of the utilities offer different baseline methods or options for their customers to choose from. These options are shown in Table 2-123 through Table 2-122.

Table 2-122: Utility Program Details Overview

Utility	Options Available	Scheduled Interruption Length	Maximum Length	Notification Required	Maximum Unscheduled Interruptions
Oncor	No	3 hours	4 hours	1 hour	25 hours
AEP (TCC & TNC)	See Table 2-123	1 hour	2 hours or 4 hours	1 hour	4, 8, or 12 interruptions
AEP SWPECO	See Table 2-124	1 hour	2 hours or 4 hours	1 hour	4 or 12 interruptions
TNMP	No	1-2 hours	4 hours	30 minutes	4 interruptions; 18 hours
CenterPoint	No	1-3 hours	4 hours	30 minutes	4 interruptions
Xcel	See Table 2-125	--	4 hours	1 hour	6 or 12 interruptions; 24 or 48 hours
Sharyland Utilities	No	1-2 hours	4 hours	1 hour	4 interruptions;18 hours
Entergy	No	1 hour	4 hours	--	4 interruptions
El Paso Electric	No	1-5 hours	5 hours	1 hour	9 interruptions; 50 hours

Table 2-123: AEP (TNC & TCC) Interruption Options

Option	Maximum of Unscheduled Interruptions	Minimum Length (hours)	Maximum Length (hours)
A	4	1	4
B	12	1	4
C	12	1	2
D	8	1	4
E	8	1	2

Table 2-124: AEP (SWEPCO) Interruption Options

Option	Maximum of Unscheduled Interruptions	Minimum Length (hours)	Maximum Length (hours)
A	4	1	4
B	12	1	4
C	12	1	2

Table 2-125: Xcel Interruption Options

Option	Maximum of Unscheduled Interruptions	Maximum Length (hours)
A	6	4
B	12	4

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

For load control devices, the energy savings is typically insignificant due the relatively short curtailment periods, so only the demand impact is addressed here[174]. IDR or Advanced Meter data associated with the project is used to calculate both the baseline demand usage for each interruption, along with the curtailment period demand usage. The Verified Demand Savings for the curtailment period uses the following algorithm:

$$\textit{Verified Demand Savings} = \textit{Baseline Period kW} - \textit{Curtailment kW}$$

Equation 111

Where:

Baseline Period kW = *Baseline average demand over the time periods listed in* Table 2-126

Curtailment kW = *Average demand measured during the curtailment period*

[174] Some utilities do determine energy savings, which would be calculated as the difference between the baseline and curtailment kW values times the length of the event.

Table 2-126: Utility Verification Plan Overview

Utility	Number of Previous Weekdays Required	Time Averaged During Previous Weekdays	Other Hours Averaged
Oncor	5	Same time as that of interruption	
AEP (TNC, TCC, SWEPCO)	4	Same time as that of interruption	
TNMP	4	Same time as that of interruption	1 hour, 2 hours before the start of curtailment
CenterPoint	4	Same time as that of interruption	1 hour, 1.5 hours before the start of curtailment
Xcel, Sharyland, El Paso Electric	4	Same time as that of interruption	1 hour, 2 hours before the start of curtailment
Entergy	4	1 hour, 2 hours before start of curtailment	1 hour, 2 hours before the start of curtailment

Measure Life and Lifetime Savings

N/A

Additional Calculators and Tools

N/A

Program Tracking Data & Evaluation Requirements

- IDR or Advanced Meter data associated with the project will be provided by the project sponsor or retrieved by the utility following an event. Depending on the utility, the data will be provided in 15[175] minute increments to evaluate both baseline demand usage and demand usage during curtailment.

References and Efficiency Standards

Petitions and Rulings

N/A

Relevant Standards and Reference Sources

- El Paso Electric: EOE 2010 Load Management Program Manual. http://www.epelectricefficiency.com/files/EPE_LM_10_ProgramManual.pdf. Accessed 09/06/2013.

[175] El Paso Electric requires 30 minute intervals.

- AEP: Texas North Company Load Management SOP 2013 Program Manual. http://www.aepefficiency.com/loadmanagement/TNC/2013_TNC_LM%20Manual_Agreement.pdf. Accessed 02/28/14.

- AEP: Texas Central Company Load Management SOP 2013 Program Manual.http://www.aepefficiency.com/loadmanagement/TCC/2013_TCC_LM%20Manual_Agreement.pdf. Accessed 09/06/2013.

- AEP: Southwestern Electric Power Company Load Management 2013 Program Manual. http://www.swepcogridsmart.com/texas/downloads/Load%20Management%20Program%20Manual.pdf. Accessed 09/06/2013

- Entergy: 2013 Load Management Handbook. http://www.entergy-texas.com/content/energy_efficiency/documents/Load_Management_Handbook.pdf. Accessed 09/06/2013.

- CenterPoint: EnergyShare 2013 Program Manual. http://www.centerpointelectric.com/staticfiles/CNP/Common/SiteAssets/doc/2013%20Load%20Management%20Program%20Manual.pdf. Accessed 09/06/2013.

- Texas-New Mexico: Load Management 2013 SOP. http://tnmpefficiency.com/downloads/Load_Management_Program_Manual.pdf. Accessed 09/06/2013.

- Xcel Energy: 2013 Load Management Pilot Standard Offer Program. http://www.xcelefficiency.com/TX/Xcel_LM_Manual_2013.pdf. Accessed 09/06/2013.

- Sharyland Utilities: 2013 Load Management SOP. http://www.sharylandefficiency.com/load-management/Sharyland%202013%20Peak%20Load%20Mgmt%20Program%20Manual.pdf. Accessed 09/06/2013.

- Oncor: Commercial Load Management Standard Offer Program. https://www.oncoreepm.com/commload.aspx. Accessed 09/06/2013.

Document Revision History

Table 2-127: Nonresidential Demand Response Load Management History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM V1.0 origin
v2.0	04/18/2014	Included details surrounding testing requirement to verify load reduction capability.

APPENDIX C: NONRESIDENTIAL LIGHTING FACTORS COMPARISON TABLES

The following appendix shows a comparison of deemed values used across utilities and implementers for the following lighting measure inputs, by building type:

- Hours of Operation (HOU)
- Coincidence Factors (CF)
- Energy Adjustment Factors (EAF)
- Power Adjustment Factors (PAF)

Table C-1: Operating Hours Building Type, By Utility[176]

Building Type Code	Building Type Description	Operating Hours		
		Docket 39146[177]	LSF Calculators[178]	Oncor Calculator[179]
Educ. K-12, No Summer	Education (K-12 w/o Summer Session)	2,777	2,777	2,777
Education, Summer	Education: College, University, Vocational, Day Care, and K-12 w/ Summer Session	3,577	3,577	3,577
Non-24-Hr Retail	Food Sales – Non-24-Hr Supermarket/Retail	4,706	4,706	4,706
24-Hr Retail	24-Hr Supermarket/Retail	6,900	6,900	6,900
Fast Food	Food Service – Fast Food	6,188	6,188	6,188
Sit-down Rest.	Food Service – Sit-down Restaurant	4,368	4,368	4,368
Health In	Health Care (In Patient)	5,730	5,730	5,730
Health Out	Health Care (Out Patient)	3,386	3,386	3,386
Lodging, Common	Lodging (Hotel/Motel/Dorm), Common Area	6,630	6,630	6,630
Lodging, Rooms	Lodging (Hotel/Motel/Dorm), Rooms	3,055	3,055	3,055
Manufacturing	Manufacturing	5,740	5,740	5,740
MF Common	Multi-family Housing, Common Areas	4,772	4,772	4,772
Nursing Home	Nursing and Residential Care	4,271	4,271	4,271
Office	Office	3,737	3,737	3,737
Outdoor	Outdoor Lighting Photo-Controlled	3,996	3,996	4,145*
Parking	Parking Structure	7,884	7,884	7,884
Public Assembly	Public Assembly	2,638	2,638	2,638
Public Order	Public Order and Safety	3,472	3,472	3,472
Religious	Religious Worship	1,824	1,824	1,824
Retail Non-mall/strip	Retail (Excl. Mall and Strip Center)	3,668	3,668	3,668

176 Discrepancies from PUCT Docket No. 39146 are denoted by an asterisk (*).
177 These values were sourced from PUCT Docket No. 39146, Table 8.
178 LSF Calculators used by Xcel, Sharyland, AEP, EPE, and Entergy. 2013 Lighting Survey Form (LSF). Specified calculator versions are: Xcel v7.01, EPE v7.02, Sharyland, v8.01.
179 Oncor Calculator, 2013 E1 – Lighting (Retrofit) and 2013 N1 – Lighting (New Construction).

Building Type Code	Building Type Description	Operating Hours		
		Docket 39146[177]	LSF Calculators[178]	Oncor Calculator[179]
Enclosed Mall	Retail (Enclosed Mall)	4,813	4,813	4,813
Strip/Non-enclosed Mall	Retail (Strip Center and Non-enclosed Mall)	3,965	3,965	3,965
Service (Non-food)	Service (Excl. Food)	3,406	3,406	3,406
Non-refrig. Warehouse	Warehouse (Non-refrigerated)	3,501	3,501	3,501
Refrig. Warehouse	Warehouse (Refrigerated)	3,798	3,798	3,798

Table C-2: Coincidence Factors Building Type, By Utility[180]

Building Type Code	Building Type Description	Coincidence Factors		
		Docket 39146[181]	LSF Calculators[182]	Oncor Calculator[183]
Educ. K-12, No Summer	Education (K-12 w/o Summer Session)	47%	47%	47%
Education, Summer	Education: College, University, Vocational, Day Care, and K-12 w/ Summer Session	69%	69%	69%
Non-24-Hr Retail	Food Sales – Non-24-Hr Supermarket/Retail	95%	95%	95%
24-Hr Retail	24-Hr Supermarket/Retail	95%	95%	95%
Fast Food	Food Service – Fast Food	81%	81%	81%
Sit-down Rest.	Food Service – Sit-down Restaurant	81%	81%	81%
Health In	Health Care (In Patient)	78%	78%	78%
Health Out	Health Care (Out Patient)	77%	77%	77%
Lodging, Common	Lodging (Hotel/Motel/Dorm), Common Area	82%	82%	82%
Lodging, Rooms	Lodging (Hotel/Motel/Dorm), Rooms	25%	25%	25%
Manufacturing	Manufacturing	73%	73%	73%
MF Common	Multi-family Housing, Common Areas	87%	87%	87%
Nursing Home	Nursing and Residential Care	78%	78%	78%
Office	Office	77%	77%	77%
Outdoor	Outdoor Lighting Photo-Controlled	0%	0% / 61%*	64%*

180 Discrepancies from PUCT Docket No. 39146 are denoted by an asterisk (*). In the event of two numbers in the cell, the first number refers to the Summer Peak CF, and the second number refers to the Winter Peak CF.

181 These values were sourced from PUCT Docket No. 39146, Table 8.

182 LSF Calculators used by Xcel, Sharyland, AEP, EPE, and Entergy. 2013 Lighting Survey Form (LSF). Specified calculator versions are: Xcel v7.01, EPE v7.02, Sharyland, v8.01.

183 Oncor Calculator, 2013 E1 – Lighting (Retrofit) and 2013 N1 – Lighting (New Construction).

Building Type Code	Building Type Description	Coincidence Factors		
		Docket 39146[181]	LSF Calculators[182]	Oncor Calculator[183]
Parking	Parking Structure	100%	100%	100%
Public Assembly	Public Assembly	56%	56%	56%
Public Order	Public Order and Safety	75%	75%	75%
Religious	Religious Worship	53%	53%	53%
Retail Non-mall/strip	Retail (Excl. Mall and Strip Center)	90%	90%	90%
Enclosed Mall	Retail (Enclosed Mall)	93%	93%	93%
Strip/Non-enclosed Mall	Retail (Strip Center and Non-enclosed Mall)	90%	90%	90%
Service (Non-food)	Service (Excl. Food)	90%	90%	90%
Non-refrig. Warehouse	Warehouse (Non-refrigerated)	77%	77%	77%
Refrig. Warehouse	Warehouse (Refrigerated)	84%	84%	84%

Table C-3: Operating Hour and Coincidence Factor Sources from Petition 39146

Table 8. Building Operating Hours and Coincidence Factors for Lighting Measures

Building Type	Operating Hours	Operating Hour Sources	Coincidence Factor	Coincidence Factor Sources
Education:K-12, w/o Summer Session	2,777	Navigant (2002) Weighted-average Calculation	0.47	RLW (2007)
Education: College, University, Vocational, Day Care, and K-12 w/ summer session	3,577	SCE (2007), weighted average calculation	0.69	RLW (2007)
Food Sales - Non-24-Hour Supermarket/Retail	4,706	CBECS (2003)/Navigant (2002), weighted ave calculation	0.95	RLW (2007)
Food Sales - 24 Hour Supermarket/Retail	6,900	Weighted Ave of Existing PUCT-Approved Value and Navigant (2002)	0.95	Existing PUCT-Approved Value
Food Service – fast food	6, 188	SCE (2007)	0.81	RLW (2007), weighted-average calculation
Food Service – Sit-down Restaurant	4,368	SCE (2007)	0.81	RLW (2007), weighted-average calculation
Health Care (Out-patient)	3,386	Navigant (2002) Weighted-average Calculation	0.77	RLW (2007)
Health Care (In-patient)	5,730	Navigant (2002) Weighted-average Calculation	0.78	See Explanation below
Lodging (Hotel/Motel/Dorm), Common Areas	6,630	Navigant (2002)Weighted-average Calculation	0.82	RLW (2007)
Lodging (Hotel/Motel/Dorm), Rooms	3,055	Navigant (2002)Weighted-average Calculation	0.25	See Explanation below
Manufacturing	5,740	Frontier Estimate	0.73	RLW (2007))
Multi-family Housing, Common Areas	4,772	Existing PUCT-Approved Value	0.87	RLW (2007)

Table C-3: (Cont.) Operating Hour and Coincidence Factor Sources from Petition 39146

Building Type	Operating Hours	Operating Hour Sources	Coincidence Factor	Coincidence Factor Sources
Nursing and Resident Care	4,271	Navigant (2002) Weighted-average Calculation	0.78	RLW (2007)
Office	3,737	Navigant (2002) Weighted-average Calculation	0.77	RLW (2007)
Outdoor (street & parking)	3996	Oncor Street Lighting Tariff Filing	0.00	Oncor Street Lighting Tariff Filing
Parking Structure	7,884	Existing PUCT-approved value	1.00	Existing PUCT-approved value
Public Assembly	2,638	Navigant (2002) Weighted-average Calculation	0.56	Conn (2007); Weighted by XENCAP Study
Public Order and Safety	3,472	Navigant (2002) Weighted-average Calculation	0.75	Conn (2007); Weighted by XENCAP Study
Religious	1,824	Navigant (2002) Weighted-average Calculation	0.53	Conn (2007); Weighted by XENCAP Study
Retail (Excluding Malls and Strip Centers)	3,668	Navigant (2002) Weighted-average Calculation	0.90	RLW (2007)
Retail (Enclosed Mall)	4,813	Navigant (2002)Weighted-average Calculation	0.93	RLW (2007)
Retail (Strip shopping and non-enclosed mall)	3,965	Navigant (2002) Weighted-average Calculation	0.90	RLW (2007)
Service (Excluding Food)	3,406	Navigant (2002) Weighted-average Calculation	0.90	RLW (2007) – assumed similar operations as Retail
Warehouse (Non-refrigerated)	3,501	Navigant (2002) Weighted-average Calculation	0.77	RLW (2007)
Warehouse (Refrigerated)	3,798	Navigant (2002) Weighted-average Calculation	0.84	RLW (2007)

Petition 39146, Table 8, References:

Navigant (2002) / XENCAP Study. Navigant Consulting, Inc. (September, 2002). U.S. Lighting Market Characterization: Volume I: National Lighting Inventory and Energy Consumption Estimate. U.S. Department of Energy Office or Energy Efficiency and Renewable Energy, Building Technologies Program.

SCE (2007) The citation for this report appears to be missing from the petition. The only SCE report in the petition is this one from 2006: Southern California Edison, Design & Engineering Services Customer Service Business Unit. (December 15, 2006). Fiber Optic Lighting in Low Temperature Reach-In Refrigerated Display Cases. Southern California Edison.

RLW (2007). United Illuminating Company and Connecticut Light & Power. Final Report, 2005 Coincidence Factor Study. http://webapps.cee1.org/sites/default/files/library/8828/CEE_Eval_CTCoincidenceFactorsC&ILightsHVAC_4Jan2007.PDF. Accessed 09/19/2013.

Oncor Street Lighting Tariff Filing. Only this general description is provided. There is no specific reference or citation.

Conn (2007). RLW Analytics. (September, 2006). CT & MA Utilities 2004-2005 Lighting Hours of Use for School Buildings Baseline Study. Prepared for Connecticut Light & Power Company, Western Massachusetts Electric Company, United Illuminating Company.

Existing PUCT-Approved Value. A specific petition is not cited, but a table is presented that "….outlines the existing M&V Guidelines approved by the PUC..".

Operating Hours Calculation spreadsheet (lmc_vol1_final_tables.xls). This spreadsheet was prepared by Frontier, and it contains the detailed calculations that are presented in Appendix A of petition 39146.

Table C-4: Lighting Power Densities, By Building Type, By Utility[184]

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[185]	LSF Calculators[186]
Automotive Facility	--	0.90	0.90
Convention Center	--	1.20	1.20
Court House	--	1.20	1.20
Dining: Bar Lounge/Leisure	--	1.30	1.30
Dining: Cafeteria/Fast Food	--	1.40	1.40
Dining: Family	--	1.60	1.60
Dormitory	--	1.00	1.00
Exercise Center	--	1.00	1.00
Gymnasium	--	1.10	1.10
Health Center	--	1.00	1.00
Hospital	--	1.20	1.20
Hotel	--	1.00	1.00
Library	--	1.30	1.30
Manufacturing Facility	--	1.30	1.30
Motel	--	1.00	1.00
Motion Picture Theater	--	1.20	1.20
Multi-family	--	0.70	0.70

184 Building Type Code has been pulled from PUCT Docket No. 39146 to show the variation between Building Type Codes used for HOU and CF, and Building Type Codes used for LPDs. Records where a Building Type Description has been listed, but no Building Type Code have been pulled from the calculator utilizing those specific LPDs. Building Types from the Lighting HOU and CF tables are denoted by an asterisk (*).

185 Oncor Calculator, 2013 N1 – Lighting (New Construction).

186 LSF Calculators used by Xcel, Sharyland, AEP, EPE, and Entergy. 2013 Lighting Survey Form (LSF). Specified calculator versions are: Xcel v7.01, EPE v7.02, Sharyland, v8.01, TNMP v4.18.

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[185]	LSF Calculators[186]
Museum	--	1.10	1.10
Penitentiary	--	1.00	1.00
Performing Arts Theater	--	1.60	1.60
Police/Fire Station	--	1.00	1.00
Post Office	--	1.10	1.10
Retail	--	1.50	1.50
School/University	--	1.20	1.20
Sports Arena	--	1.10	1.10
Town Hall	--	1.10	1.10
Transportation	--	1.00	1.00
Warehouse	--	0.80	0.80
Workshop	--	1.40	1.40
Educ K-12, No Summer*	Education (K-12 w/o Summer Session)	--	--
Education, Summer*	Education: College, University, Vocational, Day Care, and K-12 w/ Summer Session	--	--
Non-24-Hr Retail*	Food Sales – Non-24-Hr Supermarket/Retail	--	--
24-Hr Retail*	24-Hr Supermarket/Retail	--	--
Fast Food*	Food Service – Fast Food	--	--
Sit-down Rest.*	Food Service – Sit-down Restaurant	--	--
--	Food Service – Sit-down Restaurant - Dining: Bar Lounge/Leisure	--	--
Health In*	Health Care (In Patient)	--	--

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[185]	LSF Calculators[186]
Health Out*	Health Care (Out Patient)	--	--
Lodging, Common*	Lodging (Hotel/Motel/Dorm), Common Area	--	--
Lodging, Rooms*	Lodging (Hotel/Motel/Dorm), Rooms	--	--
Manufacturing*	Manufacturing	--	--
MF Common*	Multi-family Housing, Common Areas	--	--
Nursing Home*	Nursing and Residential Care	--	--
Office*	Office	1.00	1.00
--	Outdoor - Outdoor Uncovered Parking Area: Zone 1	--	0.04
--	Outdoor - Outdoor Uncovered Parking Area: Zone 2	--	0.06
--	Outdoor - Outdoor Uncovered Parking Area: Zone 3	--	0.10
--	Outdoor - Outdoor Uncovered Parking Area: Zone 4	--	0.13
Outdoor*	Outdoor Lighting Photo-Controlled	--	--
Parking*	Parking Structure	0.30	0.30
Public Assembly*	Public Assembly	--	--
--	Public Assembly - Convention Center	--	--
--	Public Assembly - Exercise Center	--	--
--	Public Assembly - Gymnasium	--	--
--	Public Assembly - Hospital	--	--
--	Public Assembly - Library	--	--
--	Public Assembly - Motion Picture Theater	--	--
--	Public Assembly - Museum	--	--
--	Public Assembly - Performing Arts Theater	--	--

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[185]	LSF Calculators[186]
--	Public Assembly - Post Office	--	--
--	Public Assembly - Sports Arena	--	--
--	Public Assembly - Transportation	--	--
--	Public Order and Safety - Court House	--	--
--	Public Order and Safety - Penitentiary	--	--
--	Public Order and Safety - Police/Fire Station	--	--
Public Order*	Public Order and Safety	--	--
Religious*	Religious Worship	1.30	1.30
Retail Non-mall/strip*	Retail (Excl. Mall and Strip Center)	--	--
Enclosed Mall*	Retail (Enclosed Mall)	--	--
Strip/Non-enclosed Mall*	Retail (Strip Center and Non-enclosed Mall)	--	--
Service (Non-food)*	Service (Excl. Food)	--	--
Non-refrig. Warehouse*	Warehouse (Non-refrigerated)	--	--
Refrig. Warehouse*	Warehouse (Refrigerated)	--	--

Table C-5: Energy Adjustment Factors By Utility[187]

Building Type Code	Control Codes	Energy Adjustment Factors			
		Docket 40668[188]	LSF Calculators[189]	Oncor Calculator (Retrofit)[190]	Oncor Calculator (New Construction)[191]
No controls measures	None	1.00	1.00	1.00	1.00
Stipulated DC - Continuous Dimming	DC- cont	0.70	0.70	0.70	0.70
Stipulated DC - Multiple Step Dimming	DC- step	0.80	0.80	0.80	0.80
Stipulated DC - ON/OFF (Indoor)	Indoor DC - on/off	0.90	0.90	0.90	0.90
Stipulated DC - ON/OFF (Outdoor)	Outdoor DC - on/off	1.00	1.00	0.64*	0.64*
Stipulated Occupancy Sensor (OS)	OS	0.70	0.70	0.70	0.70
Stipulated OS w/DC - Continuous Dimming	OS - cont	0.60	0.60	0.60	0.60
Stipulated OS w/DC - Multiple Step Dimming	OS - step	0.65	0.65	0.65	0.65
Stipulated OS w/DC - ON/OFF (Indoor)	Indoor OS - on/off	0.65	0.65	0.65	0.65
Photocontrol	Photo	--	--	1.00*	--

187 Discrepancies from PUCT Docket No. 40668 are denoted by an asterisk (*). The EAF is applicable to all building types.
188 These values were sourced from PUCT Docket No. 40668, Page A-24.
189 LSF Calculators used by Xcel, Sharyland, AEP, EPE, and Entergy. 2013 Lighting Survey Form (LSF). Specified calculator versions are: Xcel v7.01, EPE v7.02, Sharyland, v8.01, TNMP v4.18.
190 Oncor Calculator, 2013 E1 – Lighting (Retrofit).
191 Oncor Calculator, 2013 N1 – Lighting (New Construction).

Table C-6: Demand Adjustment Factors By Utility[192]

Building Type Code	Control Codes	Demand Adjustment Factors					
		Docket 40668[193]		LSF Calculators[194]		Oncor Calculator [195]	
		K-12, No Summer	All Remaining Building Types	K-12, No Summer	All Remaining Building Types	K-12, No Summer	All Remaining Building Types
No Controls Measures	None	1.00	1.00	1.00	1.00	1.00	1.00
Stipulated DC - Continuous Dimming	DC- cont	0.76	0.70	0.76	0.70	0.76	0.70
Stipulated DC - Multiple Step Dimming	DC- step	0.84	0.80	0.84	0.80	0.84	0.80
Stipulated DC - ON/OFF (Indoor)	Indoor DC - on/off	0.92	0.90	0.92	0.90	0.92	0.90
Stipulated DC - ON/OFF (Outdoor)	Outdoor DC - on/off	1.00	1.00	1.00	1.00	0.64*	0.64*
Stipulated Occupancy Sensor (OS)	OS	0.80	0.75	0.80	0.75	0.80	0.75
Stipulated OS w/DC - Continuous Dimming	OS - cont	0.72	0.65	0.72	0.65	0.72	0.65
Stipulated OS w/DC - Multiple Step Dimming	OS - step	0.76	0.70	0.76	0.70	0.76	0.70
Stipulated OS w/DC - ON/OFF (Indoor)	Indoor OS - on/off	0.76	0.70	0.76	0.70	0.76	0.70
Photocontrol	Photo	--	--	--	--	--	--

192 Discrepancies from PUCT Docket No. 40668 are denoted by an asterisk (*).
193 These values were sourced from PUCT Docket No. 40668, Page A-24.
194 LSF Calculators used by Xcel, Sharyland, AEP, EPE, and Entergy. 2013 Lighting Survey Form (LSF). Specified calculator versions are: Xcel v7.01, EPE v7.02, Sharyland, v8.01, TNMP v4.18.
195 Oncor Calculator, 2013 E1 – Lighting (Retrofit) and 2013 N1 – Lighting (New Construction).

APPENDIX D: MEASURE LIFE CALCULATIONS FOR EARLY RETIREMENT PROGRAMS

The following appendix describes the method of calculating savings for early retirement programs. This supersedes the previous Measure Life Savings found in PUCT Dockets 40083 and 40885, and is revised to clarify the understanding of the Measure Life calculations and reduce any misrepresentation of Net Present Value (NPV) of early retirement projects. These calculations are provided in the Docket [43681].

Step 1: Determine the measure life for ER and ROB components of the calculated savings:

$$\boldsymbol{Early\ Retirement\ (ER) Period = ML_{ER} = RUL}$$

Equation 112

$$\boldsymbol{Replace\ on\ Burnout\ (ROB) Period = ML_{ROB} = EUL - RUL}$$

Equation 113

Where:

RUL	=	*The remaining useful life determined from lookup tables based on the age of the replaced unit (or default age when actual age is unknown)*
EUL	=	*The estimated useful life as specified in applicable measure from Texas TRM (or approved petition)*

Step 2: Calculate the ER demand and energy savings and the ROB demand and energy savings:

$$\Delta \boldsymbol{kW_{ER} = kW_{replaced} - kW_{installed}}$$

Equation 114

$$\Delta \boldsymbol{kW_{RPB} = kW_{baseline} - kW_{installed}}$$

Equation 115

$$\Delta \boldsymbol{kWh_{ER} = kWh_{replaced} - kWh_{installed}}$$

Equation 116

$$\Delta \boldsymbol{kWh_{RPB} = kWh_{baseline} - kWh_{installed}}$$

Equation 117

Where:

ΔkW_{ER}	=	*Early retirement demand savings*
ΔkW_{ROB}	=	*Replace-on-burnout demand savings*
$kW_{replaced}$	=	*Demand of the retired system*[196]
$kW_{baseline}$	=	*Demand of the baseline ROB system*[197]
$kW_{installed}$	=	*Demand of the replacement system*[198]
ΔkWh_{ER}	=	*Early retirement energy savings*
ΔkWh_{ROB}	=	*Replace-on-burnout energy savings*
$kWh_{replaced}$	=	*Energy Usage of the retired system*[196]
$kWh_{baseline}$	=	*Energy Usage of the baseline ROB system*[197]
$kWh_{installed}$	=	*Energy Usage of the replacement system*[198]

[196] Retired system refers to the existing equipment that was in use before the retrofit has occurred.
[197] Baseline used for a replace-on-bunout project of the same type and capacity as the system being installed in the early retirement project (as specified in the applicable measure)
[198] Replacement system refers to the installed equipment that is in place after the retrofit has occured.

Step 3: Calculate the avoided capacity and energy cost contributions ot the total NPV for both the ER and ROB components:

$$NPV_{ER,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ER}}\right\} \times \Delta kW_{ER}$$

Equation 118

$$NPV_{ROB,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ROB}}\right\} \times \frac{(1+e)^{ML_{ER}}}{(1+d)^{ML_{ER}}} \times \Delta kW_{ROB}$$

Equation 119

$$NPV_{ER,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ER}}\right\} \times \Delta kWh_{ER}$$

Equation 120

$$NPV_{ROB,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ROB}}\right\} \times \frac{(1+e)^{ML_{ER}}}{(1+d)^{ML_{ER}}} \times \Delta kWh_{ROB}$$

Equation 121

Where:

$NPV_{ER,\ kW}$	=	*Net Present Value (kW) of ER projects*
$NPV_{ROB,\ kW}$	=	*Net Present Value (kW) of ROB projects*
$NPV_{ER,\ kWh}$	=	*Net Present Value (kWh) of ER projects*
$NPV_{ROB,\ kW}$	=	*Net Present Value (kWh) of ROB projects*
e	=	*Escalation Rate* [199]
d	=	*Discount rate weighted average cost of capital (per utility)* [199]
AC_{kW}	=	*Avoided cost per kW ($/kW)* [199]
AC_{kWh}	=	*Avoided cost per kWh ($/kWh)* [199]
ML_{ER}	=	*ER Measure Life (calculated in Equation 112)*
ML_{ROB}	=	*ROB measure life (calculated in Equation 113)*

Note: Demand and energy savings (ΔkW and ΔkWh) used to estimate NPV in Equation 120 through Equation 123 are the savings estimated using the same equations as have been in use for some time in the commercial HVAC programs (equations A-1 and A-2 in Petition 40083).

[199] The exact values to be used each year for the escalation rate, discount rate, and avoided costs are established by the PUC in Substantive Rule §25.181 and updated annually, as applicable. Please note that the discount rates are based on a utility's weighted average cost of capital and, as such, will vary by utility and may change each year.

However, the efficiency values used in estimating the equations differ from those used in Petitions 40083 and 40885: (1) the Early Retirement savings, earned for the RUL of the replaced system, are estimated using the difference between the efficiency of the replaced system and that of the installed system; (2) the replace-on-burnout savings, earned over the measure EUL minus the project's RUL, are estimated using the difference between the replace-on-burnout baseline efficiency and the efficiency of the installed system.

Step 4: Calculate the total capacity and energy cost contributions to the total NPV:

$$\boldsymbol{NPV_{Total,kW} = NPV_{ER,kW} + NPV_{ROB,kW}}$$

Equation 122

$$\boldsymbol{NPV_{Total,kWh} = NPV_{ER,kWh} + NPV_{ROB,kWh}}$$

Equation 123

Where:

$NPV_{Total,\ kW}$	=	*Total capacity contributions to NPV of both ER and ROB component*
$NPV_{Total,\ kWh}$	=	*Total energy contributions to NPV of both ER and ROB component*

Step 5: Calculate the capacity and energy cost contributions to the NPV without weighting by demand and energy savings for a scenario using the original EUL:

$$\boldsymbol{NPV_{EUL,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{EUL}\right\}}$$

Equation 124

$$\boldsymbol{NPV_{EUL,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{EUL}\right\}}$$

Equation 125

Where:

$NPV_{EUL,\ kW}$	=	*Capacity contributions to NPV without weighting, using original EUL*
$NPV_{Total,\ kWh}$	=	*Energy contributions to NPV without weighting, using original EUL*

Step 6: Calculate the weighted demand and energy savings by dividing the combined capacity and energy cost contributions from the ER and ROB scenarios by the non-savings weighted capacity and energy cost contributions from the single EUL scenario. These weighted savings are claimed over the original measure EUL:

$$Weighted\ kW = \frac{NPV_{Total.kW}}{NPW_{EUL,kW}}$$

Equation 126

$$Weighted\ kWh = \frac{NPV_{Total.kWh}}{NPW_{EUL,kWh}}$$

Equation 127

Where:

Weighted kW	=	*Weighted lifetime demand savings*
Weighted kWh	=	*Weighted lifetime energy savings*
$NPV_{Total,\ kW}$	=	*Total capacity contributions to NPV of both ER and ROB component, calculated in Equation 122*
$NPV_{Total,\ kWh}$	=	*Total energy contributions to NPV of both ER and ROB component, calculated in Equation 123*
$NPV_{EUL,\ kW}$	=	*Capacity contributions to NPV without weighting, using original EUL, calculated in Equation 126*
$NPV_{Total,\ kWh}$	=	*Energy contributions to NPV without weighting, using original EUL, calculated in Equation 127*