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 2-71: Deemed Energy and Demand Savings Values

Oven Size	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Full-Size	1,937	0.410
Half-Size	192	0.040

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® research122 and with the DEER 2014 EUL update (EUL ID – Cook-ElecConvOven).

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.

- High Efficiency Equipment Manufacturer and Model Number
- High Efficiency Equipment Heavy Load Cooking Efficiency
- High Efficiency Equipment Idle Rate
- Oven Size
- Verification of ENERGY STAR® certification

References and Efficiency Standards

Petitions and Rulings

N/A

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Commercial Ovens. http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens. Accessed 1/22/2015.
- ENERGY STAR® list of Qualified Commercial Ovens. http://www.energystar.gov/productfinder/download/certified-commercial-ovens. Accessed 1/22/2015
- DEER 2014 EUL update

Document Revision History

Table 2-72: Nonresidential High-Efficiency Convection Oven History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	Updated to newer ENERGY STAR® Commercial Ovens Program Requirements Version 2.1. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v3.1	11/05/2015	Updated title to reflect En ENERGY STAR® Measure.
v4.0	10/10/2016	No revisions

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 Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, Replace-on-Burnout 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, and are described in Table 2-73:

- Under Counter Dishwasher
- Stationary Rack, Single Tank, Door Type Dishwasher
- Single Tank Conveyor Dishwasher
- Multiple Tank Conveyor Dishwasher
- Pot, Pan & Utensil

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[123]

[123] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.

Dishwashers intended for use in residential or laboratory applications are not eligible for ENERGY STAR® under this product specification. Steam, gas, and other non-electric models also do not qualify.

Table 2-73: Nonresidential ENERGY STAR® Commercial Dishwashers Descriptions

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.
Pot, Pan, and Utensil	A stationary rack, door type machine designed to clean and sanitize pots, pans, and kitchen utensils.

Baseline Condition

Baseline equipment is either a low-temperature[124] or high temperature[125] machine as defined by Table 2-73, which is not used in a residential or laboratory setting. For low-temperature units, the DHW is assumed to be electrically heated. For high-temperature units, the DHW can either be heated by electric or natural gas methods. For units heated with natural gas, the unit shall have an electric booster heater attached to it.

[124] Low temperature machines apply a chemical sanitizing solution to the surface of the dishes to achieve sanitation.

[125] High temperature machines aplly only hot water to the surface of the dishes to achieve sanitation.

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 must be electric. Low temperature equipment uses chemical sanitization, and does not require a booster heater. The high efficiency dishwasher is required to have the maximum idle energy rate and water consumption as shown in Table 2-74 below.

Table 2-74: High-Efficiency Requirements for Commercial Dishwashers[126]

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
Pot, Pan and Utensil	< 1.00	≤0.58[127]	≤ 1.20	≤ 0.58[127]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

$$Energy\ Savings\ [kWh] = (V_{waterB} - V_{waterP}) \times \left(\frac{\Delta T_{DHW} + \Delta T_{boost}}{\eta_{DHW}}\right) \times \rho_{water} \times C_p \times \frac{1\ W}{3413\ kBtuh} + (Idle_{base} - Idle_{post}) \times \left(t_{days} \times t_{hours} - t_{days} \times N_{racks} \times \frac{WashTime}{60}\right)$$

Equation 67

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

Equation 68

$$V_{waterB} = t_{days} \times N_{racks} \times V_{galrackB}$$

Equation 69

[126] Table 2-74 values are provided in ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers, Version 2.0. https://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Dishwasher_Program_Requirements.pdf.

[127] Water Consumption for Pot, Pan and Utensil is specified in gallons per square foot rather than gallons per rack.

$$V_{waterP} = t_{days} \times N_{racks} \times V_{galrackP}$$

Equation 70

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.°F]*
ΔT_{DHW}	=	*Inlet water temperature increase for building water heater [°F]*
η_{DHW}	=	*Building electric water heater and booster heater efficiency [%]*
ΔT_{boost}	=	*Inlet water temperature for booster water heater [°F]*
$IDLE_{base}$	=	*Baseline Idle Energy Rate [kW]*
$IDLE_{post}$	=	*High Efficiency Idle Energy Rate [kW]*
$WashTime$	=	*Wash time per Rack*

Table 2-75: Deemed Variables for Energy and Demand Savings Calculations

Inputs	Under Counter	Door Type	Single Tank Conveyor	Multiple Tank Conveyor	Pot, Pan and Utensil
t_{days}[128]			365		
t_{hours}[5]			18		
CF			0.97		
ρ_{water}			8.208 [lbs/gallon]		
C_p			1.0 [Btu/lb °F]		
ΔT_{DHW}[4]			Gas Hot Water Heaters: 0°F Electric Hot Water Heaters: 70 °F		
η_{DHW}			98%		
ΔT_{boost}			Gas Booster Heaters: 0 °F Electric Booster Heaters: 40 °F		
η_{boost}			98%		
		Low Temperature Units			
N_{racks}	75	280	400	600	N/A
$V_{galrackB}$	1.73	2.10	1.31	1.04	N/A
$V_{galrackP}$	1.19	1.18	0.79	0.54	N/A
$IDLE_{base}$	0.50	0.60	1.60	2.00	N/A
$IDLE_{post}$	0.50	0.60	1.50	2.00	N/A
WashTime	2.0	1.5	0.3	0.3	N/A
		High Temperature Units			
N_{racks}	75	280	400	600	280
$V_{galrackB}$	1.09	1.29	0.87	0.97	0.70
$V_{galrackP}$	0.86	0.89	0.70	0.54	0.58
$IDLE_{base}$	0.76	0.87	1.93	2.59	1.20
$IDLE_{post}$	0.50	0.70	1.50	2.25	1.20
WashTime	2.0	1.0	0.3	0.2	3.0

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.

Table 2-76: Deemed Energy and Peak Demand Savings Values by Dishwasher

Facility Description	Under Counter		Door Type		Single Tank Conveyor		Multi Tank Conveyor		Pot, Pan and Utensil	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Low Temp. / Electric Hot Water Heater	2,540	0.375	16,153	2.385	13,626	2.012	18,811	2.777	NA	NA
High Temp. / Electric Hot Water Heater w/ Electric Booster Heater	3,171	0.468	11,863	1.751	9,212	1.360	27,408	4.046	3,311	0.489
High Temp. / Gas Hot Water Heater w/ Electric Booster Heater	2,089	0.308	4,840	0.715	4,948	0.730	11,230	1.658	1,204	0.178

Measure Life and Lifetime Savings

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

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 and Post-Retrofit Dishwasher Machine Type
- Post-Retrofit Make and Model Number
- Energy Source for Primary Water Heater
- Energy Source for Booster Water Heater

References and Efficiency Standards

Petitions and Rulings

N/A

[128] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 12/16/2013.

[129] California End Use Survey (CEUS), Building workbooks with load shapes by end use. http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx. Accessed 07/12/12.

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Commercial Dishwashers. http://www.energystar.gov/sites/default/files/specs//private/Commercial_Dishwasher_Program_Requirements%20v2_0.pdf. Accessed 01/30//2015.
- 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 01/30//2015.
- ENERGY STAR® v2.0 Calculator (Commercial Kitchen Equipment Savings Calculator). http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx. Accessed 01/27/2015.

Document Revision History

Table 2-77: Nonresidential ENERGY STAR® Commercial Dishwashers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
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 2-74.
v3.0	04/30/2015	Aligned calculation approach with ENERGY STAR® Commercial Dishwashers Program Requirements Version 2.0. Simplified methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	Added high-efficiency requirements for pots, pans, and utensils.

2.4.4 ENERGY STAR® Hot Food Holding Cabinets Measure Overview

TRM Measure ID: NR-FS-HC

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, Replace-on-Burnout or 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. The energy and demand savings are determined on a per-cabinet basis.

Eligibility Criteria

Hot food holding cabinets must be ENERGY STAR® certified.[130] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[131]

The following products are excluded from the ENERGY STAR® eligibility criteria:

- Dual function equipment,
- Heated transparent merchandising cabinets, and
- Drawer warmers

[130] 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.

[131] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.

Baseline Condition

Eligible baseline equipment is a half-size, three-quarter size, or full-size 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 2-78 summarizes Idle Energy Rates per ENERGY STAR® Version 2.0:

Table 2-78: Maximum Idle Energy Rate Requirements ENERGY STAR® Qualification

Product Category	Product Interior Volume [ft^3]	Idle Energy 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

* V = Interior Volume = Interior Height x Interior Width x Interior Depth

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

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

$$\boldsymbol{Energy\ Saving\ [kWh] = (E_{IdleB} - E_{IdleP}) \times \frac{1}{1000} \times t_{hrs} \times t_{days}}$$

Equation 71

$$\boldsymbol{Peak\ Demand\ [kW] = (E_{IdleB} - E_{IdleP}) \times \frac{1}{1000} \times CF}$$

Equation 72

Where:

E_{IdleB}	=	*Baseline idle energy rate [W]. See Table 2-79*
E_{IdleP}	=	*Idle energy rate after installation [W]. See Table 2-79*
V	=	*Product Interior Volume [ft^3]*
t_{hrs}	=	*Equipment operating hours per day [hrs]*
t_{days}	=	*Facility operating days per year*
CF	=	*Peak coincidence factor*

Table 2-79: Equipment Operating Hours per Day and Operating Days per Year

Input Variable	Half-Size	Three-Quarter Size	Full-Size
Product Interior Volume [ft^3]	12	20	30
Baseline Equipment Idle Energy Rate [E_{IdleB}]	480	800	1,200
Efficient Equipment Idle Energy Rate [E_{IdleP}]	258	294	318
Operating Hours per Day [t_{hours}]	15		
Facility Operating Days per Year [t_{days}]	365		
Peak Coincidence Factor[132] [CF]	0.92		

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.

Table 2-80: Deemed Energy and Demand Savings Values by HFHC Size

Size	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Half	1,215	0.204
Three-Quarter	2,770	0.466
Full	4,832	0.812

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[133] and the DEER 2014 EUL update (EUL ID - Cook-Hold Cab)

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)

[132] California End Use Survey (CEUS), Building workbooks with load shapes by end use. http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx. Accessed 07/12/12.

[133] 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%20 sp%20savings%20calc/commercial%20kitchen%20equipment%20calculator.xls. Accessed 09/14/11.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Provides EUL for Hot Food Holding Cabinets

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Hot Food Holding Cabinets. https://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_HFHC_Program_Requirements_2.0.pdf. Accessed 01/21/2015
- DEER 2014 EUL update

Document Revision History

Table 2-81: Nonresidential Hot Food Holding Cabinets History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	Updated to newer ENERGY STAR® Hot Food Holding Cabinet Program Requirements Version 2.0. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	No revisions

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 Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, 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 units must meet ENERGY STAR® qualifications, either counter-top or floor type designs, with standard-size and large vat fryers as defined by ENERGY STAR®[134].

- Standard-Size Electric Fryer: A fryer with a vat that measures ≥ 12 inches and < 18 inches wide, and a shortening capacity ≥ 25 pounds and ≤ 65 pounds.
- Large Vat Electric Fryer: A fryer with a vat that measures ≥ 18 inches and ≤ 24 inches wide, and a shortening capacity > 50 pounds.

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets[135]

The following products are excluded from the ENERGY STAR® eligibility criteria:

- Fryers with vats measuring < 12 inches wide, or > 24 inches wide

[134] ENERGY STAR® Program Requirements Product Specifications for Electric Fryers. Eligibility Criteria Version 2.0. https://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Fryers_Program_Requirements.pdf. Accessed 01/27/15.

[135] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.

Baseline Condition

Baseline fryers can be existing or new electric standard-size fryers ≥12 inches < 18 inches wide or large vat fryers > 18 inches and < 24 inches wide that do not meet ENERGY STAR® product criteria.

High-Efficiency Condition

New electric standard fryers ≥12 inches and < 18 inches wide and large vat fryers >18 inches and < 24 inches wide that meet or exceed the ENERGY STAR® requirements listed below in Table 2-82.

Table 2-82: High-Efficiency Requirements for Electric Fryers

Inputs	Standard	Large-Vat
Cooking energy efficiency	≥ 80%	≥ 80%
Idle energy rate [W]	≤ 1,000	≤ 1,100

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

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

Equation 73

$$Peak\ Demand\ [kW] = \frac{kWh_{base} - kWh_{post}}{t_{OpHrs} \times t_{days}} \times CF$$

Equation 74

$$kWh_{base} = \left(W_{food} \times \frac{E_{food}}{\eta_{cookingB}} + E_{idleB} \times \left(t_{OpHours} - \frac{W_{food}}{C_{CapB}}\right)\right) \times \frac{t_{days}}{1000}$$

Equation 75

$$kWh_{post} = \left(W_{food} \times \frac{E_{food}}{\eta_{cookingP}} + E_{idleP} \times \left(t_{OpHours} - \frac{W_{food}}{C_{CapP}}\right)\right) \times \frac{t_{days}}{1000}$$

Equation 76

Where:

kWh_{base}	=	*Baseline annual energy consumption [kWh]*
kWh_{post}	=	*Post annual energy consumption [kWh]*
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 2-83: Deemed Variables for Energy and Demand Savings Calculations[136]

Parameter	Standard-Sized Vat		Large-Vat	
	Baseline	Post Retrofit	Baseline	Post Retrofit
kWh_{base}	See Table 2-79			
kWh_{post}				
W_{food}	150			
t_{OpHors}	16		12	
t_{days}	365			
CF[137]	0.92			
E_{food}	167			
$\eta_{cooking}$	75%	80%	70%	80%
E_{idle}	1,050	1,000	1,350	1,110
C_{Cap}	65	70	100	110

Deemed Energy and Demand Savings Tables

The energy and demand savings of Electric Fryers are deemed values. Table 2-84 provides these deemed values.

Table 2-84: Deemed Energy and Demand Savings Values by Fryer Type

Fryer Type	kWh_{base}	kWh_{post}	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Standard	17,439	16,488	952	0.150
Large Vat	18,236	15,700	2,536	0.533

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).

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.

- Manufacturer and Model Number
- High Efficiency Unit Heavy Load Cooking Efficiency

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[136] Deemed input values come from ENERGY STAR® Commercial Kitchen Equipment Calculator. http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx. Accessed 01/30/2015.

[137] California End Use Survey (CEUS), Building workbooks with load shapes by end use. http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx. Accessed 07/12/12,

- High Efficiency Unit Equipment Idle Rate
- Fryer Width
- Verification of ENERGY STAR® certification

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779 – Provides EUL for Electric Fryers

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Electric Fryers https://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Fryers_Program_Requirements.pdf. Accessed 01/22/2015.
- DEER 2014 EUL update

Document Revision History

Table 2-85: Nonresidential Electric Fryers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	Updated to newer ENERGY STAR® Electric Fryers Program Requirements Version 2.1. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	No revisions

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 2-87

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.[138]

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.[139]

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

[139] 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:

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

Equation 77

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

Equation 78

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 (°F)*
T_C	=	*Average supply (cold) water temperature (°F)*
Days	=	*Annual facility operating days for the applications*
C_H	=	*Unit Conversion: 8.33 BTU/ (Gallons-°F)*
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 2-86: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
F_B	1.6[138]
F_P	1.25[138,139]
$U_B = U_P$	Fast Food Restaurant: 45 min/day/unit[140] Casual Dining Restaurant: 105 min/day/unit[140] Institutional: 210 min/day/unit[140] Dormitory: 210 min/day/unit[140] K-12 School: 105 min/day/unit[141]
T_H	120[142]
T_C	69[143]
Days[144]	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[145]	Fast Food Restaurant: 6.81% Casual Dining Restaurant: 17.36% Institutional: 5.85% Dormitory: 17.36% K-12 School: 11.35%

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

141 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.

142 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.

143 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.

144 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.

145 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 2-87: 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.[138,143] This is consistent with PUCT Docket No. 36779.

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 2-88: 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.
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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 Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, Replace-on-Burnout or 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 Steam Cookers can have a 3, 4, 5 or 6 pan capacity. A list of eligible equipment is found on the ENERGY STAR® list of qualified equipment.[146] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets[147]

Baseline Condition

Eligible baseline condition for retrofit situations are electric Steam Cookers that are not ENERGY STAR® certified.

High-Efficiency Condition

The high efficiency electric steam cookers are assumed to be ENERGY STAR® certified and have the characteristics shown in Table 2-89.

[146] 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.

[147] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.

Table 2-89: ENERGY STAR® Energy Efficiency and Idle Rate Requirements for Electric Steam Cookers[148]

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

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

Equation 79

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

Equation 80

$$kWh_{base} = W_{food} \times \frac{E_{food}}{\eta_{base}} + \left((1 - \eta_{tSteam}) \times E_{idleRate,base} + \eta_{tSteam} \times C_{pan} \times N_{pan} \times \frac{E_{food}}{\eta_{base}} \right) \times \left(t_{days} - \frac{W_{food}}{\eta_{base} \times N_{pan}} \right) \times \frac{N_{OpDays}}{1000}$$

Equation 81

$$kWh_{post} = W_{food} \times \frac{E_{food}}{\eta_{post}} + \left((1 - \eta_{tSteam}) \times E_{idleRate,post} + \eta_{tSteam} \times C_{pan} \times N_{pan} \times \frac{E_{food}}{\eta_{post}} \right) \times \left(t_{days} - \frac{W_{food}}{\eta_{post} \times N_{pan}} \right) \times \frac{N_{OpDays}}{1000}$$

Equation 82

Where:

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

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

ΔkWh = *Energy Savings = $kWh_{base} - kWh_{post}$*

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

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

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

η_{base}	=	*Baseline Cooking energy efficiency (Differs for boiler-based or steam generator equipment)*
η_{post}	=	*Post-Retrofit Cooking energy efficiency*
η_{tSteam}	=	*Percent of time in constant steam mode [%]*
$E_{IdleRate,\ base}$	=	*Idle energy rate [W]. (Differs for boiler-based or steam-generator equipment)*
$E_{IdleRate,\ post}$	=	*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*
1000	=	*Wh to kWh conversion factor*

Table 2-90: Deemed Variables for Energy and Demand Savings Calculations[149]

Parameter	Baseline Value	Post Retrofit Value
kWh_{base}	See Table 2-91Table 2-91	
kWh_{post}		
W_{food}	100	
E_{food}	30.8	
η	Boiler-based Efficiency: 26% Steam-Generator Efficiency: 30%	50%
η_{tSteam}	40%	
$E_{IdleRate}$	Boiler-based Idle Rate: 1,000 Steam Generator Idle Rate: 1,200	3-Pan: 400 4-Pan: 530 5-Pan: 670 6-Pan: 800
C_{pan}	23.3	16.7
N_{pan}	3, 4, 5, or 6	
$t_{OpHours}$	12	
N_{OpDays}	365	

[149] 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.

Parameter	Baseline Value	Post Retrofit Value
CF[150]	0.92	

Table 2-91: Annual Energy Consumption and Daily Food Cooked[151]

Steam Cooker Type	N_{pan}	kWh_{base}	kWh_{Post}	Annual Energy Savings [kWh]	Peak Demand Savings [kW]
Boiler Based	3-Pan	19,416	7,632	11,784	2.475
	4-Pan	24,330	9,777	14,553	3.057
	5-Pan	29,213	11,946	17,268	3.627
	6-Pan and Larger	34,080	14,090	19,990	4.199
Steam Generator	3-Pan	17,599	7,632	9,967	2.093
	4-Pan	21,884	9,777	12,107	2.543
	5-Pan	26,132	11,946	14,186	2.980
	6-Pan and Larger	30,360	14,090	16,270	3.417

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.

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).

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.

- High Efficiency Manufacturer and Model number
- Number of Pans
- Verification of ENERGY STAR® certification

150 California End Use Survey (CEUS), Building workbooks with load shapes by end use. http://capabilities.the EM&V team.com/CeusWeb/Chart.aspx. Accessed 07/12/12.

151 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/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx

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. https://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Steam_Cookers_Program_Requirements.pdf. Accessed 01/22/2015.
- DEER 2014 EUL update

Document Revision History

Table 2-92: 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.
v3.0	04/10/2015	Updated to newer ENERGY STAR® Steam Cooker Program Requirements Version 1.2. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	No revisions

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 83

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 42.89°F DP and all on (duty cycle of 100%) at 52.87°F for a typical supermarket. Between these values, the door heaters' duty cycle changes proportionally:

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

Equation 84

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:

For medium temperature

kW_{Ash} = 0.109 per door or 0.0436 per linear foot of door[152,153]

For low temperature

kW_{Ash} = 0.191 per door or 0.0764 per linear foot of door[154,155]

Equation 85

152 (Pennsylvania TRM) State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs Deemed Savings Manual, March 22, 2010.

153 Three door heater configurations are presented: Standard, low-heat, and no-heat. The standard configuration was chosen on the assumption that low-heat and no-heat door cases will be screened from participation.

154 (Pennsylvania TRM) State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs Deemed Savings Manual, March 22, 2010.

155 Three door heater configurations are presented: Standard, low-heat, and no-heat. The standard configuration was chosen on the assumption that low-heat and no-heat door cases will be screened from participation.

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

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

Equation 86

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

Equation 87

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[156], 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 88

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[157].

For medium temperature compressors, the following equation is used to determine the EER_{MT} [Btu/hr/watts]. These values are shown in Table 2-93.

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

Equation 89

Where:

a	=	*3.75346018700468*
b	=	*-0. 049642253137389*

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

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

c	=	*29.4589834935596*
d	=	*0.000342066982768282*
e	=	*-11.7705583766926*
f	=	*-0.212941092717051*
g	=	*-1.46606221890819 x* 10^{-6}
h	=	*6.80170133906075*
I	=	*-0.020187240339536*
j	=	*0.000657941213335828*
PLR	=	*1/1.15 = 0.87*
SCT	=	*ambient design temperature+ 15*

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

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

Equation 90

Where:

a	=	*9.86650982829017*
b	=	*-0.230356886617629*
c	=	*22.905553824974*
d	=	*0.00218892905109218*
e	=	*-2.48866737934442*
f	=	*-0.248051519588758*
g	=	*-7.57495453950879 x* 10^{-6}
h	=	*2.03606248623924*
i	=	*-0.0214774331896676*
j	=	*0.000938305518020252*
PLR	=	*1/1.15 = 0.876956521739*

SCT = *ambient design temperature+10*

Table 2-93: Values Based on Climate Zone City

Climate Zone	Summer Design Dry Bulb Temp[158]	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 91

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

Equation 92

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 93

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

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

Equation 94

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 95

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.

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

Table 2-94: 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	364	0.007	668	0.015
Dallas	249	0.005	457	0.011
El Paso	405	0.008	745	0.018
Houston	180	0.003	330	0.007
McAllen	137	0.003	251	0.006

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).

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 2-95: 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.
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	Update Deemed kW_{ash} for Medium temperature cases and add kW_{ash} for Low temperature cases. Added more significant digits to the input variables a-j for Equation 89 and Equation 90.

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:

Cooler

$$Demand[kW] = N \times \Delta kW_{peak\,per\,unit}$$

Equation 96

$$\Delta kW_{peak\,per\,unit} = (W_{base} - W_{ee})/1000 \times LF \times DC_{EvapCool} \times \left(1 + \frac{1}{COP_{cooler}}\right)$$

Equation 97

$$Energy[kWh] = N \times \Delta kWh_{per\,unit}$$

Equation 98

$$\Delta kWh_{per\,unit} = \Delta kW_{peak\,per\,unit} \times Hours \times (1 - \%OFF)$$

Equation 99

Freezer

$$Demand[kW] = N \times \Delta kW_{peak\,per\,unit}$$

Equation 100

$$\Delta kW_{peak\,per\,unit} = (W_{base} - W_{ee})/1000 \times LF \times DC_{EvapFreeze} \times \left(1 + \frac{1}{COP_{freezer}}\right)$$

Equation 101

$$Energy[kWh] = N \times \Delta kWh_{per\,unit}$$

Equation 102

$$\Delta kWh_{per\,unit} = \Delta kW_{peak\,per\,unit} \times Hours \times (1 - \%OFF)$$

Equation 103

Where:

N	=	*Number of Motors replaced*
W_{base}	=	Input wattage of existing/baseline evaporator fan motor
W_{ee}	=	Input wattage of new energy efficient evaporator fan motor
LF	=	Load factor of evaporator fan motor
$DC_{EvapCool}$	=	Duty cycle of evaporator fan motor for cooler
$DC_{EvapFreeze}$	=	Duty cycle of evaporator fan motor for freezer
COP_{cooler}	=	Coefficient of performance of compressor in the cooler
$COP_{freezer}$	=	Coefficient of performance of compressor in the freezer
Hours	=	the annual operating hours are assumed to be 8,760 for cases and 8,273 for walk-ins
%OFF	=	The Percentage of time that the evaporator fan motors are off. If the facility does not have evaporator fan controls %OFF = 0, if the facility has evaporator fan controls %OFF = 46%.

Table 2-96: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
W_{base}	See Table 2-97
W_{ee}	See Table 2-97
LF[159]	0.9
$DC_{EvapCool}$[160]	100%
$DC_{EvapFreeze}$[161]	94.4%
COP_{cooler}	See Table 2-98
$COP_{freezer}$	See Table 2-98
Hours[162]	8760 or 8273[163]
%OFF	0 or 46%

Table 2-97: Motor Sizes, Efficiencies and Input Watts[164]

Motor Eff. & Power Table							
Nominal Motor Size	Motor Output (W)	Shaded Pole Eff	Shaded Pole Input (W)	PSC Eff	PSC Input (W)	ECM Eff.	ECM Input (W)
(1-14W)	9	18%	50	41%	22	66%	14
1/40 HP (16-23W)	19.5	21%	93	41%	48	66%	30
1/20 HP (37W)	37	26%	142	41%	90	66%	56
1/15 HP (49W)	49.0	26%	188	41%	120	66%	74
1/4 HP	186.5	33%	559	41%	455	66%	283
1/3 HP	248.7	35%	714	41%	607	66%	377

159 "ActOnEnergy; Business Program-Program Year 2, June, 2009 through May, 2010. Technical Reference Manual, No. 2009-01." Published 12/15/2009

160 "Efficiency Maine; Commercial Technical Reference User Manual No. 2007-1." Published 3/5/07.

161 Ibid

162 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.

163 Efficiency Vermont, Technical Reference Manual 2009-54, 12/08. Hours of operation accounts for defrosting periods where motor is not operating. http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf

164 The first four rows are from the Pennsylvania TRM and the last two rows are estimated using logarithmic linear regression of smaller motor efficiencies.

Table 2-98: Compressor Coefficient of Performance Based on Climate and Refrigeration Type (COP_{cooler} or $COP_{freezer}$)

Representative Climate City	Summer Design Dry Bulb Temperature, ASHRAE Fundamentals 2009	COP_{cooler}	$COP_{freezer}$
Amarillo	96	1.88	1.46
Fort Worth	100	1.77	1.37
El Paso	101	1.74	1.35
Houston	96	1.89	1.46
McAllen	100	1.77	1.37

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).

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
- 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 2-99: Nonresidential ECM Evaporator Fan Motors History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	Updated the methodology with cooler and freezer values.

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 104

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

Equation 105

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

Equation 106

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

Equation 107

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 2-100: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
DRF[165]	35%
Eff_{MT}[166]	Amarillo: 1.86 Dallas-Ft. Worth: 1.98 El Paso: 2.02 Houston: 1.86 McAllen: 1.98
Eff_{LT}[166]	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.[167]

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)

[165] 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.

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

[167] 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 2-101: Nonresidential Electronic Defrost Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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 108

$$\boldsymbol{Peak\ Demand\ [kW] =}$$

$$\boldsymbol{\left((kW_{evap} \times n_{fans}) - kW_{circ}\right) \times (1 - DC_{comp}) \times DC_{evap} \times BF}$$

Equation 109

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 2-102: Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed Values
kW_{evap}[168]	0.123 kW
kW_{circ}[169]	0.035 kW
DC_{comp}[170]	50%
DC_{evap}[171]	Cooler: 100% Freezer: 94%
BF[172]	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).

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
- Refrigeration Temperature

168 Based on an a weighted average of 80% shaded pole motors at 132 watts and 20% PSC motors at 88 watts.

169 Wattage of fan used by Freeaire and Cooltrol.

170 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.

171 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).

172 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.

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 2-103: Nonresidential Evaporator Fan Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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.[173]
- Infiltration accounts for approximately 24% of the total cooling load of open horizontal (coffin or tub style) display cases.[173]

Installing night covers for a period of 6 hours per night can reduce the cooling load due to infiltration by:

- 8% on vertical cases[173]
- 50% on horizontal cases[174]

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.

a. 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 110

The compressor power requirements are based on calculated cooling load and energy-efficiency ratios (EER) obtained from manufacturers' data.

b. Determine the saturated condensing temperature (SCT)

For Medium Temperature (MT): $\boldsymbol{SCT = DB_{adj} + 15}$

Equation 111

[173] ASHRAE 2006. Refrigeration Handbook. Retail Food Store Refrigeration and Equipment. Atlanta, Georgia. p. 46.1, p. 46.5, p. 46.10.

[174] 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.

For Low Temperature (LT): $SCT = DB_{adj} + 10$

Equation 112

Where:

DB_{adj} = *Design dry-bulb temperature (°F), based on climate zone, of ambient or space where the compressor/condensing units reside. Table 2-104 below lists design dry-bulb temperatures by climate zone.*

Table 2-104: Various Climate Zone Design Dry Bulb Temperatures and Representative Cities

Representative Climate Zone	Summer Design Dry Bulb Temperature, ASHRAE Climatic Region Data, 0.5% (°F)[175]
Amarillo, TX	96
Dallas-Ft. Worth, TX	100
El Paso, TX	101
Houston, TX	96
McAllen, TX	100

c. Determine the EER for both MT and LT applications

d. 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.[176]

e. 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:

$$PLR = \frac{Q_{cooling}}{Q_{capacity}}$$

Equation 113

Where:

PLR = *Part Load Ratio*

$Q_{cooling}$ = *Cooling Load*

[175] ASHRAE 2009 Handbook Fundamentals.
[176] Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.0.2007).

$Q_{capacity}$ = *Total Compressor Capacity*[177]

$$Q_{capacity} = Q_{cooling} \times 1.15$$

$$PLR = \frac{1}{1.15} = 0.87$$

To simplify the analysis, it is assumed that PLR remains constant for the post-retrofit condition.

f. 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).

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

Equation 114

Where:

a = *3.75346018700468*

b = *-0.049642253137389*

c = *29.4589834935596*

d = *0.000342066982768282*

e = *-11.7705583766926*

f = *-0.212941092717051*

g = $-1.46606221890819 \times 10^{-6}$

h = *6.80170133906075*

i = *-0.020187240339536*

j = *0.000657941213335828*

g. 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).

[177] Compressor capacity is determined by multiplying baseline cooling load by a compressor over-sizing factor of 15%.

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

Equation 115

Where:

a	=	*9.86650982829017*
b	=	*-0.230356886617629*
c	=	*22.905553824974*
d	=	*0.00218892905109218*
e	=	*-2.48866737934442*
f	=	*-0.248051519588758*
g	=	*-7.57495453950879 x 10^{-6}*
h	=	*2.03606248623924*
i	=	*-0.0214774331896676*
j	=	*0.00938305518020252*

h. Convert EER to kW/ton

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

Equation 116

i. 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 117

j. Total annual baseline refrigeration energy consumption is the sum of all bin values.

$$kWh_{baseline-refrig} = \sum kWh_{baseline-refrig-bin}$$

Equation 118

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:

$$Q_{post-retrofit}[ton - hours] = \frac{Q_{baseline-infiltration}\,[Btuh] \times Daytime_{bin-hrs}}{12{,}000\,\left[\frac{Btuh}{ton}\right]} + \frac{(Q_{baseline-infiltration}\,[Btuh] - Q_{reduced-infiltration}\,[Btuh]) \times Nighttime_{bi}}{12{,}000\,\left[\frac{Btuh}{ton}\right]}$$

Equation 119

Steps 2 through 7 are repeated in the post-retrofit case to calculate the post retrofit energy and demand usage.

k. The 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 120

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.[178] The deemed energy and demand savings are shown below.

Table 2-105: 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).

[178] 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.

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

Document Revision History

Table 2-106: 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.
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	Added more significant digits to the input variables a-j for Equation 114 and Equation 115.

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 2-108).

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 in Table 2-107.

Table 2-107: Baseline Energy Consumption[179,180]

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 2-108 below:

Table 2-108: Efficient Energy Consumption[181]

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 2-107 and Table 2-108, based on the volume of the units.

[179] 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.

[180] V = Interior volume [ft3] of a refrigerator or freezer (as defined in the Association of Home Appliance Manufacturers Standard HRF1-1979).

[181] ENERGY STAR® Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency. Accessed on 07/7/10. http://www.energystar.gov/ia/partners/product_specs/program_reqs/commer_refrig_glass_prog_req.pdf

The savings calculations are found below.

$$Energy\ [kWh] = (kWh_{base} - kWh_{ee}) \times 365$$

Equation 121

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{8760} \times CF$$

Equation 122

Where:

kWh_{base}	=	*Baseline maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 2-107.*
kWh_{ee}	=	*Efficient maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 2-108.*
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)*[182]

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[183].

[182] 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.

[183] 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 2-109: Nonresidential Solid and Glass Door Refrigerators and Freezers History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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

Measure Description

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 doorframe.

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.

Energy and Demand Savings Methodology

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 doorframe, and are shown below in Table 2-110.

Table 2-110: Deemed Energy and Demand Savings for Freezers and Coolers[184]

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).

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

[184] 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.

Document Revision History

Table 2-111: Nonresidential Walk-In Refrigerator and Freezer Strip Curtains History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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 0°F.

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 °F). 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 savings from the installation of ZERO ENERGY DOORS are a result from eliminating the heater (kWhASH) and the reduction in load on the refrigeration (kWhrefrig). 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:

$$t_{d-in} = 0.005379 \times t_{d-out}^{2} + 0.171795 \times t_{d-out} + 19.87006$$

Equation 123

The baseline assumes door heats are running on 8,760 operation. In the post-retrofit case, it is assumed that the door heaters will be all off (duty cycle of 0%).

The instantaneous door heater power (kW_{ASH}) as a resistive load remains constant is per linear foot of door heater at:

For medium temperature

kW_{Ash} = 0.109 per door or 0.0436 per linear foot of door

For low temperature

kW_{Ash} = 0.191 per door or 0.0764 per linear foot of door

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

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

Equation 124

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

Equation 125

To calculate energy savings from the reduced refrigeration load using average system efficiency and assuming that 35 percent of the anti-sweat heat becomes a load on the refrigeration system[185], 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 126

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

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[186].

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

Table 2-93:

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

Equation 127

Where:

a	=	*3.75346018700468*
b	=	*-0.049642253137389*
c	=	*29.4589834935596*
d	=	*0.000342066982768282*
e	=	*-11.7705583766926*
f	=	*-0.212941092717051*
g	=	$-1.46606221890819 \times 10^{-6}$
h	=	*6.80170133906075*
I	=	*-0.020187240339536*
j	=	*0.000657941213335828*
PLR	=	*0.87*
SCT	=	*ambient design temperature+ 15*

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

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

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

Equation 128

Where:

a	=	*9.86650982829017*
b	=	*-0.230356886617629*
c	=	*22.905553824974*
d	=	*0.00218892905109218*
e	=	*-2.4886737934442*
f	=	*-0.248051519588758*
g	=	*-7.57495453950879 x* 10^{-6}
h	=	*2.03606248623924*
i	=	*-0.0214774331896676*
j	=	*0.000938305518020252*
PLR	=	*0.87*
SCT	=	*ambient design temperature+10*

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 129

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

Equation 130

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 131

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

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

Equation 132

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 133

Table 2-112: Deemed Energy and Demand Savings Values by Location and Refrigeration Temperature in kWh per Linear Foot of Display Case

Zero Energy Door	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	1132	0.129	2074	0.237
Dallas	1143	0.131	2101	0.240
El Paso	1147	0.131	2109	0.241
Houston	1132	0.129	2074	0.237
McAllen	1143	0.131	2101	0.240

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).

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 2-113: Nonresidential Zero-Energy Refrigerated Case Doors History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	Updated savings methodology to be consistent with the door heater controls measure.

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 2-114: Deemed Energy and Demand Savings Values by Equipment Type

Size	Annual Energy Savings [kWh]	Peak Demand Savings [kW][187]
Control for Refrigerated Cold Drink Unit cans or bottles	1,612[188]	0.030
Control for Refrigerated Reach-in Unit any sealed beverage	1,086[189]	0.035
Control for Non-Refrigerated Snack Unit with lighting (include. Warm beverage)	387[190]	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).

<u>Program Tracking Data & Evaluation Requirements</u>

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

[187] 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.
[188] Pacific Gas and Electric, Work Paper VMCold, Revision 3, August, 2009, Measure Code R97.
[189] Pacific Gas and Electric, Work Paper VMReach, Revision 3, August, 2009, Measure Code R143.
[190] 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 2-115: Nonresidential Vending Machine Controls History

TRM Version	Date	Description of Change
v1.0	11/25/2013	TRM v1.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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.[191] 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 5°F or 10°F 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.

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).

[191] 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.

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[192] 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.[193]

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.

[192] 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.

[193] A more detailed description of the modeling assumptions can be found in Docket 40668 Attachment A, pages A-46 through A-58.

Table 2-116: Deemed Energy and Demand Savings for Motel per Guest Room, by Region

Representative City (Region)[194]	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 2-117: 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

194 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".

Representative City (Region)	Heat Pump				Electric Heat			
	HVAC-Only		HVAC & Lighting		HVAC-Only		HVAC & Lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
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

Table 2-118: 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[195]. This value is also consistent with the EUL for lighting control and HVAC control measures in PUCT Docket Nos. 36779 and 40668.

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)

[195] 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 2-119: Lodging Guest Room Occupancy Controls History

TRM Version	Date	Description of Change
v2.0	04/18/2014	TRM v2.0 origin
v2.0	04/18/2014	No revisions
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

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[196]" 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[197] 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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[196] 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.

[197] 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*[198] (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*[199], 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[200].

Savings Algorithms and Inputs

The energy and demand algorithms and associated input variables are listed below:

$$\boldsymbol{Energy\,Savings\,[kWh] = kW_{avg} * (TimeClock\%On - POC\%On) * 8760}$$

Equation 134

$$\boldsymbol{Demand\,Savings\,[kW] = \frac{EnergySavings}{8760}}$$

Equation 135[201]

The inputs for the energy and peak coincident demand savings are listed below:

$$\boldsymbol{kW_{avg} = HP \times 0.746 \times \frac{\frac{LF}{ME}}{SME}}$$

Equation 136

$$\boldsymbol{POC\%On = \frac{Run_{Constant} + Run_{Coefficient} \times VolumetricEfficiency\% \times TimeClock\%On \times 100}{100}}$$

Equation 137[202]

198 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).

199 *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.

200 The EM&V Team will work with SPS/Xcel Energy in developing the sample plan for the field data collection effort.

201 The equations in the petition for peak demand simplify to the equation shown.

202 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 2-120
ME	=	*Motor efficiency, based on NEMA Standard Efficiency Motor, see Table 2-121*
SME	=	*Mechanical efficiency of sucker rod pump, see Table 2-120*
TimeClock%On	=	*Stipulated baseline timeclock setting, see Table 2-120*
$Run_{constant}$, $Run_{coefficient}$	=	*8.336, 0.956. Derived from SPE 16363*[203]
VolumetricEfficiency%	=	*Average well gross production divided by theoretical production (provided on rebate application)*

Deemed Energy and Demand Savings Tables

Table 2-120: Deemed Variables for Energy and Demand Savings Calculations

Variable	Stipulated/ Deemed Values
LF (Load Factor)	25%[204]
ME (motor efficiency)	See Table 2-121
SME (pump mechanical efficiency)	95%[205]
Timeclock%On	65%[206]

[203] 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).

[204] *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.

[205] Engineering estimate for standard gearbox efficiency.

[206] 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.

Table 2-121: NEMA Premium Efficiency Motor Efficiencies[207]

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 135.

Measure Life and Lifetime Savings

The EUL for this measure is 15 years[208].

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)

[207] 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.

[208] 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.

- 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[209]

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]
- 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 2-122: Pump-off Controller History

TRM Version	Date	Description of Change
v2.1	01/30/2015	TRM v2.1 origin
v3.0	04/10/2015	No revisions
v4.0	10/10/2016	No revisions

[209] 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.

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. Note the calculators used may not represent the most recent calculators, and are only provided here as a snapshot comparison of similarities and differences across utilities.

- Hours of Operation (HOU)
- Coincidence Factors (CF)
- Energy Adjustment Factors (EAF)
- Power Adjustment Factors (PAF)

Table C-0-1: Operating Hours Building Type, By Utility[210]

Building Type Code	Building Type Description	Operating Hours		
		Docket 39146[211]	LSF Calculators[212]	Oncor Calculator[213]
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

210 Discrepancies from PUCT Docket No. 39146 are denoted by an asterisk (*).
211 These values were sourced from PUCT Docket No. 39146, Table 8.
212 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.
213 Oncor Calculator, 2013 E1 – Lighting (Retrofit) and 2013 N1 – Lighting (New Construction).

Building Type Code	Building Type Description	Operating Hours		
		Docket 39146[211]	LSF Calculators[212]	Oncor Calculator[213]
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
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-0-2: Coincidence Factors Building Type, By Utility[214]

Building Type Code	Building Type Description	Coincidence Factors		
		Docket 39146[215]	LSF Calculators[216]	Oncor Calculator[217]
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%*
Parking	Parking Structure	100%	100%	100%
Building Type Code	Building Type Description	Coincidence Factors		

[214] 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.

[215] These values were sourced from PUCT Docket No. 39146, Table 8.

[216] 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.

[217] Oncor Calculator, 2013 E1 – Lighting (Retrofit) and 2013 N1 – Lighting (New Construction).

		Docket 39146[218]	LSF Calculators[219]	Oncor Calculator[220]
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%

[218] These values were sourced from PUCT Docket No. 39146, Table 8.

[219] 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.

[220] Oncor Calculator, 2013 E1 – Lighting (Retrofit) and 2013 N1 – Lighting (New Construction).

Table C-0-3: 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-0-4: Lighting Power Densities, By Building Type, By Utility[221]

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[222]	LSF Calculators[223]
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

221 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 (*).

222 Oncor Calculator, 2013 N1 – Lighting (New Construction).

223 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[222]	LSF Calculators[223]
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)	--	--
Health Out*	Health Care (Out Patient)	--	--

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[222]	LSF Calculators[223]
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		
	Public Assembly - Post Office		

Building Type Code	Building Type Description	Lighting Power Density (LPD) or New Construction	
		Oncor Calculator[222]	LSF Calculators[223]
--	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-0-5: Energy Adjustment Factors By Utility[224]

Building Type Code	Control Codes	Energy Adjustment Factors			
		Docket 40668[225]	LSF Calculators [226]	Oncor Calculator (Retrofit)[227]	Oncor Calculator (New Construction)[228]
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*	--

224 Discrepancies from PUCT Docket No. 40668 are denoted by an asterisk (*). The EAF is applicable to all building types.
225 These values were sourced from PUCT Docket No. 40668, Page A-24.
226 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.
227 Oncor Calculator, 2013 E1 – Lighting (Retrofit).
228 Oncor Calculator, 2013 N1 – Lighting (New Construction).

Table C-0-6: Demand Adjustment Factors By Utility[229]

Building Type Code	Control Codes	Demand Adjustment Factors					
		Docket 40668[230]		LSF Calculators[231]		Oncor Calculator [232]	
		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	--	--	--	--	--	--

229 Discrepancies from PUCT Docket No. 40668 are denoted by an asterisk (*).
230 These values were sourced from PUCT Docket No. 40668, Page A-24.
231 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.
232 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:

$$Early\ Retirement\ (ER)Period = ML_{ER} = RUL$$

Equation 138

$$Replace\ on\ Burnout\ (ROB)Period = ML_{ROB} = EUL - RUL$$

Equation 139

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:

$$\Delta kW_{ER} = kW_{replaced} - kW_{installed}$$

Equation 140

$$\Delta kW_{RPB} = kW_{baseline} - kW_{installed}$$

Equation 141

$$\Delta kWh_{ER} = kWh_{replaced} - kWh_{installed}$$

Equation 142

$$\Delta kWh_{RPB} = kWh_{baseline} - kWh_{installed}$$

Equation 143

Where:

ΔkW_{ER}	=	*Early retirement demand savings*
ΔkW_{ROB}	=	*Replace-on-bumout demand savings*
$kW_{replaced}$	=	*Demand of the retired system*[233]
$kW_{baseline}$	=	*Demand of the baseline ROB system*[234]
$kW_{installed}$	=	*Demand of the replacement system*[235]
ΔkWh_{ER}	=	*Early retirement energy savings*
ΔkWh_{ROB}	=	*Replace-on-bumout energy savings*
$kWh_{replaced}$	=	*Energy Usage of the retired system*[233]
$kWh_{baseline}$	=	*Energy Usage of the baseline ROB system*[234]
$kWh_{installed}$	=	*Energy Usage of the replacement system*[235]

233 Retired system refers to the existing equipment that was in use before the retrofit has occurred.
234 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)
235 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 of 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 144

$$NPV_{ROB,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ROB}}\right\} \times \frac{(1+e)^{ML_{ER}}}{(1+d)^{ML_{ER}}} \times \Delta kW_{ROB}$$

Equation 145

$$NPV_{ER,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ER}}\right\} \times \Delta kWh_{ER}$$

Equation 146

$$NPV_{ROB,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ROB}}\right\} \times \frac{(1+e)^{ML_{ER}}}{(1+d)^{ML_{ER}}} \times \Delta kWh_{ROB}$$

Equation 147

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*
$NPV_{ROB,\ kWh}$	=	*Net Present Value (kWh) of ROB projects*
e	=	*Escalation Rate* [236]
d	=	*Discount rate weighted average cost of capital (per utility)* [236]
AC_{kW}	=	*Avoided cost per kW ($/kW)* [236]
AC_{kWh}	=	*Avoided cost per kWh ($/kWh)* [236]
ML_{ER}	=	*ER Measure Life (calculated in Equation 138)*
ML_{ROB}	=	*ROB measure life (calculated in Equation 139)*

<u>**Note:**</u> Demand and energy savings (ΔkW and ΔkWh) used to estimate NPV in **Equation 144** through **Equation 147** 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). 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

[236] 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.

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:

$$NPV_{Total,kW} = NPV_{ER,kW} + NPV_{ROB,kW}$$

Equation 148

$$NPV_{Total,kWh} = NPV_{ER,kWh} + NPV_{ROB,kWh}$$

Equation 149

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:

$$NPV_{EUL,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{EUL}\right\}$$

Equation 150

$$NPV_{EUL,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{EUL}\right\}$$

Equation 151

Where:

$NPV_{EUL,\ kW}$	=	*Capacity contributions to NPV without weighting, using original EUL*
$NPV_{EUL,\ kWh}$	=	*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 152

$$Weighted\ kWh = \frac{NPV_{Total.kWh}}{NPW_{EUL,kWh}}$$

Equation 153