Table 129. Deemed Variables for Energy and Demand Savings Calculations

Inputs	Under counter	Single door type	Single tank conveyor	Multiple tank conveyor	Pot, pan and utensil
t_{days}[239]					365
t_{hours}					18
CF[240]					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
Wash Time	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
Wash Time	2.0	1.0	0.3	0.2	3.0

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

[240] California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12/12.

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 130. 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 with 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 with Electric Booster Heater	2,089	0.308	4,840	0.715	4,948	0.730	11,230	1.658	1,204	0.178

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL varies per eligible dishwasher type, as stated in the ENERGY STAR® v2.0 Commercial Kitchen Equipment Savings Calculator[241]. The Equipment Lifetime is tabulated per Dishwasher type in Table 131.

Table 131. Equipment Lifetime per Dishwasher Category

Machine type	EUL (years)
Under Counter	10
Stationary Single Tank Door	15
Single Tank Conveyor	20
Multiple Tank Conveyor	20
Pot, Pan, and Utensil	10

[241] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 07/2020.

Program Tracking Data and 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 manufacturer and model number
- Energy source for primary water heater
- Energy source for booster water heater
- Copy of ENERGY STAR® certification
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

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 07/2020.
- 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 07/2020.
- 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 07/2020.

Document Revision History

Table 132. Nonresidential ENERGY STAR® Commercial Dishwashers Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Update savings based on the newest version of ENERGY STAR® deemed input variables.
v2.1	01/30/2015	TRM v2.1 update. Corrections to Water Use per Rack in Table 2-90.

TRM version	Date	Description of change
v3.0	04/30/2015	TRM v3.0 update. 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	TRM v4.0 update. Added high-efficiency requirements for pots, pans, and utensils.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed EStar qualification requirement and defers to meeting criteria.

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, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

A commercial Hot Food Holding Cabinet is a heated, fully enclosed compartment with one or more solid or transparent doors designed to maintain the temperature of hot food that has been cooked using a separate appliance. Models that meet ENERGY STAR® specifications incorporate better insulation, thus 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 within the cabinet from top to bottom. The energy and demand savings are deemed and based on 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.[242] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[243]

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

- Dual function equipment (e.g., "cook-and-hold" and proofing units)

[242] A list of ENERGY STAR® qualified products can be found on the ENERGY STAR® website: https://www.energystar.gov/products/commercial_food_service_equipment/commercial_hot_food_holding_cabinets. Accessed 11/13/19.

[243] 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.

- Heated transparent merchandising cabinets
- Drawer warmers

Baseline Condition

The baseline condition 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 must be compliant with the current ENERGY STAR® v2.0 specification, effective October 1, 2011. Table 133 summarizes idle energy rate requirementbased on cabinet interior volume.

Table 133. Maximum Idle Energy Rate Requirements ENERGY STAR® Qualification[244]

Product interior volume (ft^3)	Idle energy rate (W)
0 < V < 13	≤ 21.5 V
13 ≤ V < 28	≤ 2.0 V + 254.0
28 ≤ V	≤ 3.8 V + 203.5

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

Deemed values are calculated using the following algorithms:

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

Equation 99

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

Equation 100

Where:

E_{IdleB} = *Baseline idle energy rate [W] (See Table 134)*

E_{IdleP} = *Idle energy rate after installation [W] (See Table 134)*

[244] V = Interior Volume = Interior Height x Interior Width x Interior Depth. Additionally, Table 133 is pulled from the ENERGY STAR® Program Requirements for Commercial Hot Food Holding Cabinets document, Table 1 "Maximum Idle Energy Rate Requirements for ENERGY STAR® Qualification." https://www.energystar.gov/sites/default/files/specs/private/Commercial_HFHC_Program_Requirements_2.0.pdf.

V	=	*Product Interior Volume [ft³]*
t_{hrs}	=	*Equipment operating hours per day [hrs]*
t_{days}	=	*Facility operating days per year*
CF	=	*Peak coincidence factor*

Table 134. Deemed Variables for Energy and Demand Savings Calculations

Input variable	Product interior volume range		
	0 < V < 13	13 ≤ V < 28	28 ≤ V
Assumed Product Interior Volume (ft^3)	8	22	53
Baseline Equipment Idle Energy Rate (E_{IdleB})[245]	40 × V		
Assumed Baseline Equipment Idle Energy Rate (E_{IdleB})	320	880	2,120
Efficient Equipment Idle Energy Rate (E_{IdleP})	21.5 × V	2 × V + 254	3.8 × V +203.5
Operating Hours per Day (t_{hours})	15		
Facility Operating Days per Year (t_{days})	365		
Peak Coincidence Factor[246] (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 135. Deemed Energy and Demand Savings Values by HFHC Size

Product interior volume (ft^3)	Annual energy savings (kWh)	Peak demand Savings (kW)
0 < V < 13	1,215	0.204
13 ≤ V < 28	2,770	0.466
28 ≤ V	4,832	0.812

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

245 Calculated as per the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment. https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx. Accessed 07/2020.

246 California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12/12.

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

Program Tracking Data and 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
- Copy of ENERGY STAR® certification
- Copy of proof of purchase including date of purchase, manufacturer, and model number

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.

[247] 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." https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx. Accessed 11/13/19.

Document Revision History

Table 136. Nonresidential ENERGY STAR® Hot Food Holding Cabinets Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. 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	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed EStar qualification requirement and defers to meeting criteria.

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, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section presents the deemed savings methodology for the installation of an ENERGY STAR® Electric Fryer. Fryers that 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.®[248]

- 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 and industrial foodservice operations, healthcare, hospitality, and supermarkets.[249]

[248] ENERGY STAR® Program Requirements Product Specifications for Electric Fryers. Eligibility Criteria Version 2.0. https://www.energystar.gov/sites/default/files/specs/private/Commercial_Fryers_Program_Requirements.pdf. Accessed 11/13/19.

[249] 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.

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

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

Baseline Condition

The baseline condition is an electric standard-size fryer ≥ 12 inches and < 18 inches wide or large vat fryer > 18 inches and < 24 inches wide that do not meet ENERGY STAR® product criteria.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® specification, effective October 2016. 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 requirements listed in Table 137.

Table 137. High-Efficiency Requirements for Electric Fryers

Inputs	Standard	Large-vat
Cooking energy efficiency	≥ 83%	≥ 80%
Idle energy rate (W)	≤ 800	≤ 1,100

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed values are calculated using the following algorithms:

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

Equation 101

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

Equation 102

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

Equation 103

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

Equation 104

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 138. Deemed Variables for Energy and Demand Savings Calculations[250]

Parameter	Standard-sized vat		Large vat	
	Baseline	Post retrofit	Baseline	Post retrofit
kWh_{base}	See Table 139			
kWh_{post}				
W_{food}	150			
t_{OpHrs}	16		12	
t_{days}	365			
CF[251]	0.92			
E_{food}	167			
$\eta_{cooking}$	75%	83%	70%	80%
E_{idle}	1,050	800	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 139 provides these deemed values.

Table 139. 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	15,063	2,376	0.374
Large Vat	18,236	15,739	2,497	0.525

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 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 per the PUCT approved Texas EUL filing (Docket No. 36779) and by the DEER 2014 EUL update (EUL ID—Cook-ElecFryer).

250 Deemed input values come from ENERGY STAR® Commercial Kitchen Equipment Calculator. https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx. Accessed 08/2020.

251 California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12/12.

Program Tracking Data and 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
- High-efficiency unit equipment idle rate
- Fryer width
- Copy of ENERGY STAR® certification
- Copy of proof of purchase including date of purchase, manufacturer, and model number

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/sites/default/files/specs/private/Commercial_Fryers_Program_Requirements.pdf. Accessed 11/13/2019.
- DEER 2014 EUL update.

Document Revision History

Table 140. Nonresidential ENERGY STAR® Electric Fryers Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. 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	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Savings and efficiencies revised for EnergyStar® 3.0 specifications. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed EStar qualification requirement and defers to meeting criteria.

2.4.6 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, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of ENERGY STAR® electric Steam Cookers. Steam cookers are available in 3, 4, 5, or ≥ 6 pan capacities. ENERGY STAR® qualified units are up to 50 percent 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.[252] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets[253].

It is required that the post-retrofit ENERGY STAR® electric Steam Cooker and the conventional Steam Cooker it replaces are of equivalent pan capacities.

Baseline Condition

The eligible baseline condition for retrofit situations is an electric steam cooker that is not ENERGY STAR® certified.

---

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

[253] 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.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® specification, effective August 2003. Qualified products must meet the requirements from Table 141.

Table 141. ENERGY STAR® Energy Efficiency and Idle Rate Requirements for Electric Steam Cookers[254]

Pan Capacity	Cooking Energy Efficiency (%)[255]	Idle Rate (W)
3-Pan	50%	400
4-Pan	50%	530
5-Pan	50%	670
6-Pan and Larger	50%	800

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

Equation 105

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

Equation 106

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

Equation 107

[254] ENERGY STAR®. "Commercial Steam Cookers Key Product Criteria.". https://www.energystar.gov/products/commercial_food_service_equipment/commercial_steam_cookers. Accessed 11/13/19.

[255] Cooking Energy Efficiency is based on "heavy load (potato) cooking capacity," i.e., 12 by 20 by 2½ inch (300 by 500 by 65 mm) perforated hotel pans each filled with 8.0 ± 0.2 lb (3.6 ± 0.1 kg) of fresh, whole, US No. 1, size B, red potatoes.

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

Equation 108

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]*
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 142. Deemed Variables for Energy and Demand Savings Calculations[256]

Parameter	Baseline value	Post retrofit value
kWh_{base}	See Table 143	
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_{OpHrs}	12	
N_{OpDays}	365	
CF[257]	0.92	

[256] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 09/26/11. Equipment specifications from 2009 Food Service Technology Center (FSTC) research on available models. Equipment cost from 2010 EPA research on available models using AutoQuotes. https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx. Accessed 11/13/19.

[257] California End Use Survey (CEUS), Building workbooks with load shapes by end use. http://capabilities.itron.com/CeusWeb/Chart.aspx. Accessed 07/12/12.

Deemed Energy and Demand Savings Tables

The energy and demand savings of high efficiency steam cookers are deemed by substituting the assumed input values from Table 141 into the savings algorithms, and are tabulated in Table 143 per steam cooker type and per pan capacity.

Table 143. Annual Energy Consumption and Daily Food Cooked[258]

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

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 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 both ENERGY STAR® specifications and DEER 2014 EUL update (EUL ID—Cook-ElecStmCooker).

258 The pre- and post- energy values are calculated using the ENERGY STAR® calculator and the inputs from **Error! Reference source not found.** and Table 142. http://www.energystar.gov/buildings/sites/default/uploads/files/Commercial_kitchen_equipment_calculator.xlsx.

Program Tracking Data and 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
- Copy of ENERGY STAR® certification
- Copy of proof of purchase including date of purchase, manufacturer, and model number

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/sites/default/files/specs/private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf. Accessed 11/13/2019.
- DEER 2014 EUL update.

Document Revision History

Table 144. Nonresidential ENERGY STAR® Electric Steam Cookers Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Updated EUL based on ENERGY STAR® and DEER 2014.
v3.0	04/10/2015	TRM v3.0 update. 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	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.

2.4.7 ENERGY STAR® Commercial Ice Makers Measure Overview

TRM Measure ID: NR-FS-IM

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: Any commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to automatic ice makers installed in commercial sites.

Eligibility Criteria

Eligible equipment includes air-cooled batch and continuous ice makers with the following design types: ice-making head (IMH), self-contained (SCU), and remote condensing (RCU) units.

Any commercial-type building is eligible; building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[259]

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

- Water-cooled ice makers
- Ice makers with ice and water dispensing systems
- Air cooled RCUs that are designed only for connection to remote rack compressors

Baseline Condition

The baseline condition is an ice maker meeting the federal standards published in 10 CFR 431 listed in Table 145. The baseline applies to automatic air-cooled commercial ice maker with capacities between 50 and 4,000 pounds per 24-hour period manufactured on or after January 28, 2018.

---

[259] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://library.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_January2015.pdf. Accessed 07/2020.

Table 145. Ice Maker Baseline Efficiency[260]

Equipment type	Harvest rate (lbs ice per 24 Hrs)	Max energy use rate (kWh/100 lb ice) H=harvest rate
Batch		
IMH	< 300	10 - 0.01233H
	≥ 300 and < 800	7.05 - 0.0025H
	≥ 800 and < 1,500	5.55 - 0.00063H
	≥ 1,500 and < 4,000	4.61
RCU (but not Remote Compressor)	< 988	7.97 - 0.00342H
	≥ 988 and < 4,000	4.59
RCU and Remote Compressor	< 930	7.97 - 0.00342H
	≥ 930 and < 4,000	4.79
SCU	< 110	14.79 - 0.0469H
	≥ 110 and < 200	12.42 - 0.02533H
	≥ 200 and < 4,000	7.35
Continuous		
IMH	< 310	9.19 - 0.00629H
	≥ 310 and < 820	8.23 - 0.0032H
	≥ 820 and < 4,000	5.61
RCU (but not Remote Compressor)	< 800	9.7 - 0.0058H
	≥ 800 and < 4,000	5.06
RCU and Remote Compressor	< 800	9.9 - 0.0058H
	≥ 800 and < 4,000	5.26
SCU	< 200	14.22 - 0.03H
	≥ 200 and < 700	9.47 - 0.00624H
	≥ 700 and < 4,000	5.1

[260] Code of Federal Regulations, Title 10 Part 431 for air-cooled batch-type and continuous-type automatic commercial ice maker with capacities between 50 and 4,000 pounds per 24-hour period manufactured on or after January 28, 2018. https://www.law.cornell.edu/cfr/text/10/431.136.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v3.0 specification, effective January 28, 2018. Qualified products must meet the minimum energy consumption (kWh/100 lbs ice)from Table 146.

Table 146. ENERGY STAR® Criteria—Automatic Ice Makers[261]

Equipment type	Harvest rate (lbs ice per 24 Hrs)	Max energy use rate (kWh/100 lb ice) H=harvest rate
	Batch	
IMH	H < 300	< 9.20 - 0.01134H
	300 ≤ H < 800	< 6.49 - 0.0023H
	800 ≤ H < 1500	< 5.11 - 0.00058H
	1500 ≤ H ≤ 4000	< 4.24
RCU	H < 988	< 7.17 – 0.00308H
	988 ≤ H ≤ 4000	< 4.13
SCU	H < 110	< 12.57 - 0.0399H
	110 ≤ H < 200	< 10.56 - 0.0215H
	200 ≤ H ≤ 4000	< 6.25
	Continuous	
IMH	H < 310	< 7.90 – 0.005409H
	310 ≤ H < 820	< 7.08 – 0.002752H
	820 ≤ H ≤ 4000	< 4.82
RCU	H < 800	< 7.76 – 0.00464H
	800 ≤ H ≤ 4000	< 4.05
SCU	H < 200	< 12.37 – 0.0261H
	200 ≤ H < 700	< 8.24 – 0.005429H
	700 ≤ H ≤ 4000	< 4.44

Energy and Demand Savings Methodology

Average Harvest Rates per design-type were computed for both batch and continuous Ice Makers utilizing the ENERGY STAR® qualified products listing for Commercial Ice Makers[262] for the purpose of possibly deeming energy and demand savings, but were determined to be too variable to be utilized as assumptions in computed deemed savings. A strictly algorithmic

[261] ENERGY STAR® Commercial Ice Maker Key Product Criteria Version 3.0, https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria, Accessed August 2019.

[262] A list of ENERGY STAR® qualified products can be found on the ENERGY STAR® website: https://www.energystar.gov/productfinder/product/certified-commercial-ice-machines/results. Accessed 08/2020.

approach was thus opted for. Savings for air-cooled batch and continuous Commercial Ice Makers are dependent on the Harvest Rate and can be calculated using the following algorithms.

Savings Algorithms and Input Variables

$$Annual\ Energy\ Savings\ [kWh] = (UseRate_{base} - UseRate_{\mathrm{ESTAR}}) \times \frac{Harvest\ Rate}{100} \times Duty\ Cycle \times Days$$

Equation 109

$$Demand\ Savings\ [kW] = Annual\ Energy\ Savings\ \times PLS$$

Equation 110

Where:

$UseRate_{base}$ = *The rated energy consumption (kWh) per 100 pounds of ice, Table 145 of the baseline machine.*

$UseRate_{ESTAR}$ = *The rated energy consumption (kWh) per 100 pounds of ice,*

Harvest Rate = *Pounds of ice produced per 24 hours*

Duty Cycle = *Machine duty cycle, 80%*[263]

Days = *Number of days per year, default is 365 based on continuous use for both batch and continuous type ice makers.*

PLS = *Probability-weighted peak load share, Table 147*

Table 147. Probability-Weighted Peak Load Share—Ice Makers

Probability weighted peak load share (PLS)[264]		
Climate zone	Summer peak	Winter peak
1	0.00012	0.00011
2		0.00011
3		0.00011
4		0.00012
5		0.00012

263 The assumed duty cycle value of 80% is taken from a PGE Emerging Technologies study, ET Project #ET12PGE3151 Food Service Technology—Efficient Ice Machines and Load Shifting, average duty cycle of preexisting machines in tables ES1 and ES2.

264 Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from the EPRI Load Shape Library 6.0. ERCOT regional End Use Load Shapes for Commercial Refrigeration. Peak Season, Peak Weekday values used for summer calculations. Off Peak Season, Peak Weekday values used for winter calculations. http://loadshape.epri.com/enduse. Accessed August 2019.

Deemed Energy Savings Tables

There are no deemed energy savings tables for this measure.

Deemed Summer and Winter Demand Savings Tables

There are no deemed demand savings tables for this measure.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for automatic ice makers is 8.5 years.[265]

Program Tracking Data and Evaluation Requirements

It is required that the following list of primary inputs and contextual data be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Machine type
  - IMH, RC, or SCU
  - Batch or continuous
- Machine harvest rate
- Climate zone
- Annual days of use

References and Efficiency Standards

Petitions and Rulings

None.

Relevant Standards and Reference Sources

- ENERGY STAR® Commercial Ice Maker Key Product Criteria Version 3.0, https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria, Accessed August 2020.

[265] Department of Energy, Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers, 80 FR 4698, https://www.federalregister.gov/d/2015-00326/p-4698.

Document Revision History

Table 148. Nonresidential Commercial Ice Makers Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.4.8 Demand Controlled Kitchen Ventilation Measure Overview

TRM Measure ID: NR-FS-KV

Market Sector: Commercial

Measure Category: Food Service

Applicable Building Types: Restaurants

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed value

Savings Methodology: Algorithms

Measure Description

This measure presents deemed savings for implementation of demand controlled ventilation (DCV) installed in commercial kitchens. DCV systems make use of control strategies to modulate exhaust fans and make-up air units. Various control strategies may be implemented such as time-of-day scheduling; sensors including exhaust temperature, cook surface temperature, smoke, or steam sensors; or direct communication from cooking equipment to the DCV processor.

Eligibility Criteria

Kitchen ventilation systems both with or without dedicated makeup air units are eligible for this measure.

Baseline Condition

The baseline condition is a commercial kitchen operating the cooking exhaust and make-up air operation at a single fixed speed with on/off controls or operating on an occupancy-based schedule.

High-Efficiency Condition

The efficient condition is a commercial kitchen varying the flow rates of cooking exhaust and make-up air operation based on periods of high and low demand as indicated by schedules or monitors of cooktop operation.

Energy and Demand Savings Methodology

Energy savings are calculated based on monitoring data gathered during field studies conducted by the Food Service Technology Center (FSTC) and published in the ASHRAE Journal.[266] Assumptions for average savings, operating hours and days, and makeup air factors are calculated as the averages for corresponding building types from FSTC monitoring data.

When there is no dedicated makeup air unit, only the exhaust fan power is expected to modulate based on demand and a makeup air unit factor is applied to the savings algorithm. The makeup air unit (MAU) factor is calculated as the percent of total kitchen ventilation system power (exhaust plus makeup air fans) that comes from exhaust fans.

Interactive heating and cooling savings are taken by multiplying the percent airflow savings from the FSTC study by the estimated heating and cooling loads output by the FSTC Outdoor Air Load Calculator (OALC).[267] This output is adjusted by population to account for the percentage of sites with electric resistance or heat pump heating.[268] Additionally, because output from the OALC is per 1,000 CFM, a CFM per HP ratio[269] is applied in order to simplify implementation tracking requirements. Interactive heating and cooling savings are presented per horsepower. Assumed efficiency of AC systems is 10 EER; assumed efficiency of electric resistance heating is 1.0 COP; assumed efficiency of HP heating is 7.7 HSPF.

Savings Algorithms and Input Variables

$$kWh_{savings} = HP_{exhaust} \times (Savings_{interactive/HP} + AvgSav_{kWh/_{HP}} \times Hrs_{day} \times Days_{yr} \times MAU)$$

Equation 111

$$kW_{savings} = kWh_{savings} \times PWPLS$$

Equation 112

Where:

$AvgSav_{kWh/_{HP}}$ = *Average hourly energy savings per horsepower based on the building type, see Table 149*

$HP_{exhaust}$ = *Total exhaust horsepower of the kitchen ventilation system included in the DCV operating strategy, facility specific*

[266] Fisher, D., Swierczyna, R., and Karas, A. (February 2013) Future of DCV for Commercial Kitchens. *ASHRAE Journal,* 48-53.

[267] Food Service Technology Center Outdoor Air Load Calculator. No longer available online.

[268] Percentage of buildings with electric resistance and heat pump heat are taken from the Energy Information Administration 2012 Commercial Buildings Energy Survey (CBECS), tables b.28 Primary space-heating energy sources and b.38 Heating equipment, using data for buildings with cooking. https://www.eia.gov/consumption/commercial/data/2012. Accessed August 2020.

[269] The CFM per HP ratio was calculated using data from Southern California Edison, ET 07.10 Report on Demand Control Ventilation for Commercial Kitchen Hoods, June 2009.

Hrs_{day}	=	*Average daily operating hours, facility specific; if unknown, use defaults from Table 149*
$Days_{yr}$	=	*Number of operational days per year, facility specific; if unknown use defaults from Table 149*
MAU	=	*Make-up Air Unit factor applied to account for presence of dedicated MAU; value = 1 if there is a dedicated MAU; see Table 149 for values when there is no dedicated MAU*
$Savings_{interactive/HP}$	=	*Interactive heating savings per 1,000 CFM of outdoor air; see Table 150*
$PWPLS$	=	*Probability Weighted Peak Load Share; see Table 151*

Table 149. Demand Controlled Kitchen Ventilatio— Default Assumptions

Building type	$AvgSav_{kWh/_{HP}}$	Hrs_{day}	$Days_{yr}$	MAU factor with no dedicated MAU
Casual Dining/Fast Food[270]	0.650	15	365	0.65
24-Hr Restaurant/Hotel[271]	0.631	24	365	0.65
School Café with summer[272]	0.566	11	325	0.51
School Café without summer	0.566	11	252	0.51

Table 150. Demand Controlled Kitchen Ventilation—Population-Adjusted Interactive HVAC Savings per hp

Climate zone	Building type	Interactive savings (kWh/hp)
1	Casual Dining/Fast Food	608
	24-Hr Restaurant/Hotel	851
	School Café with summer	455
	School Café without summer	206
2	Casual Dining/Fast Food	1,123
	24-Hr Restaurant/Hotel	1,758
	School Café with summer	838
	School Café without summer	409

270 Pennsylvania TRM, "3.5.3 High-Efficiency Fan Motors for Walk-In Refrigerated Cases". Page 369, Table 3-93. June 2016.

271 All values are the average of Hotel Restaurant data from Future of DCV for Commercial Kitchens.

272 Savings and MAU are calculated as the average of University Dining data from Future of DCV for Commercial Kitchens; Hours per day and Days per year are calculated using operating hours from Table 149.

Climate zone	Building type	Interactive savings (kWh/hp)
3	Casual Dining/Fast Food	1,191
	24-Hr Restaurant/Hotel	1,844
	School Café with summer	959
	School Café without summer	571
4	Casual Dining/Fast Food	1,393
	24-Hr Restaurant/Hotel	2,262
	School Café with summer	1,119
	School Café without summer	689
5	Casual Dining/Fast Food	1,023
	24-Hr Restaurant/Hotel	1,510
	School Café with summer	775
	School Café without summer	450

Table 151. Demand Controlled Kitchen Ventilation—Probability Weighted Peak Load Share[273]

Climate zone	Summer PWPLS	Winter PWPLS
1	1.33E-04	1.46E-04
2	1.36E-04	1.45E-04
3	1.34E-04	1.43E-04
4	1.31E-04	1.45E-04
5	1.45E-04	1.46E-04

Deemed Energy and Demand Savings Tables

Table 152. Demand Controlled Kitchen Ventilation—Deemed Annual Energy Savings per hp

Climate zone	Building type	Annual savings (kWh/hp)	
		With dedicated MAU	Without dedicated MAU
1	Casual Dining/Fast Food	4,253	2,990
	24-Hr Restaurant/Hotel	6,376	4,418
	School Café with summer	2,480	1,498
	School Café without summer	1,779	1,016
2	Casual Dining/Fast Food	4,768	3,504
	24-Hr Restaurant/Hotel	7,282	5,324
	School Café with summer	2,864	1,881
	School Café without summer	1,981	1,218

273 PWPLS factors are calculated according to the methods described in TRM Volume 1, Section 4.3. The load shape source is the Pacific Northwest National Laboratory Technical Support Document: 50% Energy Savings for Quick-Service Restaurants, Table B.4, Schedule for Kitchen exhaust flow.

Climate zone	Building type	Annual savings (kWh/hp)	
		With dedicated MAU	Without dedicated MAU
3	Casual Dining/Fast Food	4,836	3,572
	24-Hr Restaurant/Hotel	7,368	5,410
	School Café with summer	2,985	2,002
	School Café without summer	2,144	1,381
4	Casual Dining/Fast Food	5,038	3,775
	24-Hr Restaurant/Hotel	7,787	5,829
	School Café with summer	3,144	2,162
	School Café without summer	2,261	1,499
5	Casual Dining/Fast Food	4,668	3,404
	24-Hr Restaurant/Hotel	7,034	5,077
	School Café with summer	2,801	1,818
	School Café without summer	2,023	1,260

Table 153. Demand Controlled Kitchen Ventilation—Deemed Summer and Winter Peak Demand Savings per hp

Climate zone	Building type	Summer demand savings (kWh/hp)		Winter demand savings (kWh/hp)	
		With dedicated MAU	Without dedicated MAU	With dedicated MAU	Without dedicated MAU
1	Casual Dining/Fast Food	0.57	0.40	0.62	0.44
	24-Hr Restaurant/Hotel	0.85	0.59	0.93	0.65
	School Café with summer	0.33	0.20	0.36	0.22
	School Café without summer	0.24	0.14	0.26	0.15
2	Casual Dining/Fast Food	0.65	0.48	0.69	0.51
	24-Hr Restaurant/Hotel	0.99	0.72	1.05	0.77
	School Café with summer	0.39	0.26	0.41	0.27
	School Café without summer	0.27	0.17	0.29	0.18
3	Casual Dining/Fast Food	0.65	0.48	0.69	0.51
	24-Hr Restaurant/Hotel	0.99	0.72	1.05	0.77
	School Café with summer	0.40	0.27	0.43	0.29
	School Café without summer	0.29	0.18	0.31	0.20
4	Casual Dining/Fast Food	0.66	0.50	0.73	0.55
	24-Hr Restaurant/Hotel	1.02	0.76	1.13	0.85
	School Café with summer	0.41	0.28	0.46	0.31
	School Café without summer	0.30	0.20	0.33	0.22

Climate zone	Building type	Summer demand savings (kWh/hp)		Winter demand savings (kWh/hp)	
		With dedicated MAU	Without dedicated MAU	With dedicated MAU	Without dedicated MAU
5	Casual Dining/Fast Food	0.68	0.49	0.68	0.50
	24-Hr Restaurant/Hotel	1.02	0.74	1.03	0.74
	School Café with summer	0.41	0.26	0.41	0.27
	School Café without summer	0.29	0.18	0.30	0.18

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

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

Program Tracking Data and 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.

- Kitchen ventilation system exhaust fan horsepower
- Building type
- Kitchen ventilation makeup air unit fan horsepower, if present
- Presence of dedicated makeup air unit
- Testing and balancing report, if available

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 154. Nonresidential Demand Controlled Kitchen Ventilation Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.4.9 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 156

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Direct install or point of sale

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of pre-rinse sprayers to reduce hot water usage which, in turn, saves 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 and are algorithmically based.

Eligibility Criteria

Units must be used for commercial food preparation only and have flow rates which are no greater than the baseline flow rates specified in Table 155 (on a per product class or ozf, i.e. spray force in ounce-force, basis).

Baseline Condition

Effective January 28, 2019, eligible baseline equipment is a pre-rinse spray valve with a flow-rate that does not exceed the maximum flow rate per product class as specified in Table 155.[274]

Table 155. Pre-Rinse Spray Valve Flow Rate Limits

Product class (ozf)	Flow rate (gpm)
Product Class 1 (≤ 5 ozf)	1.00
Product Class 2 (> 5 ozf and ≤ 8 ozf)	1.20
Product Class 3 (> 8 ozf)	1.28

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

High-Efficiency Condition

Following the passing of the Energy Policy Act of 2005, the EPA announced on September 21st, 2005 that it would no longer pursue an ENERGY STAR® specification for Pre-rinse Spray Valves[275]. Rather than simply disallowing pre-rinse spray valves altogether, it has been decided that the savings resulting from the retrofitting of this measure be algorithm-based (as opposed to deemed using baseline and high-efficiency assumptions). If identification of a standard flow rate for post-retrofit equipment can be identified, future updates will address the transformation of this measure from an algorithm-based approach to one which is deemed.

The eligible high-efficiency equipment is thus a pre-rinse spray valvewhich has a flow rate no greater than the flow rate specified in Table 155 for the pre-rinse spray valve's respective product class. The sprayer should be capable of the same cleaning ability as the old sprayer.[276]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy and demand savings are calculated using the following algorithms:

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

Equation 113

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

Equation 114

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*

275 "Summary of ENERGY STAR® Specification Development Process and Rationale for PreRinse Spray Valves". March 2006. https://www.energystar.gov/ia/partners/prod_development/downloads/PRSV_Decision_Memo_Final.pdf?1e37-d3b8.

276 FEMP Performance Requirements for Federal Purchases of Pre-rinse Spray Valves, Based on ASTM F2324-03: Standard Test Method for Pre-rinse Spray Valves.

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 156. Assumed Variables for Energy and Demand Savings Calculations

Variable	Assumed value
F_B	See Table 155
$U_B = U_P$	Fast Food Restaurant: 45 min/day/unit[277] Casual Dining Restaurant: 105 min/day/unit[277] Institutional: 210 min/day/unit[277] Dormitory: 210 min/day/unit[277] K-12 School: 105 min/day/unit[278]
T_H	120[279]
T_C	69[280]

[277] "CEE Commercial Kitchens Initiative Program Guidance on pre-rinse valves", page 3. Midpoint of typical hours of operation in footnoted building types. https://library.cee1.org/system/files/library/4252/PRSV%20Program%20Guidance.pdf.

[278] 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.

[279] 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.

[280] 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.

Variable	Assumed value
Days[281]	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[282]	Fast Food Restaurant: 6.81% Casual Dining Restaurant: 17.36% Institutional: 5.85% Dormitory: 17.36% K-12 School: 11.35%

Deemed Energy and Demand Savings Tables

There are no deemed energy or demand savings tables for this measure. Please see the High-Efficiency Condition section for the rationale used in opting for an algorithm-based approach.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 5 years.[274,280] This is consistent with PUCT Docket No. 36779.

---

[281] 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.

[282] 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. https://www.gearteamju.com/GC/Home/Engineering/Hvac%20I/sheets/Ashrae-2011%20Hvac%20Applications%20Si%20-%20GearTeam.pdf.

Program Tracking Data and 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.

- Spray force in ounce-force (ozf)
- 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: https://interchange.puc.texas.gov/Documents/40669_3_735684.PDF. Accessed 09/09/2013.
- PUCT Docket 36779—Provides EUL for pre-rinse sprayers

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 157. Nonresidential Pre-Rinse Spray Valves Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. 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	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.4.10 Vacuum-Sealing & Packaging Machines Measure Overview

TRM Measure ID: NR-MS-VS

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Supermarket, Grocery, Food Store

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: M&V

Measure Description

This measure involves the replacement of always-on commercial electric vacuum-sealing and packaging machines with on-demand commercial electric vacuum-sealing and packaging machines. Packaging machines consist of a heating bar and heating platform. The heating bar is used to cut the wrapping film as it meets the heating bar. The heating platform is used to heat up the wrapping film. When the wrapping film is heated, the film sticks to the package and seals the product.

Eligibility Criteria

Eligible vacuum-sealing and packaging machines must use either a mechanical or optical control system. A mechanical system applies downward pressure onto a larger heating element platform, engaging a switch that activates a heating element until the switch is disengaged (or for a maximum of three seconds). An optical system uses an optical eye to detect that an item is being sealed. The eye is placed in the front center of a large heating element. When a package is set on the heating element, light is reflected into the eye, engaging the heating element until it is removed (or for a maximum of three seconds).

The measure is restricted to supermarket, grocery, and other food store building types.

Baseline Condition

The baseline is a conventional (always-on) packaging machine. With conventional machines, both heating elements are kept at a constant temperature of 280°F.

High-Efficiency Condition

The high-efficiency condition is an on-demand packaging machine. On-demand machines are similar but have a more powerful heating platform, which is defaults to off and is switched on/off by a controller.

Savings Algorithms and Input Variables

Southern California Edison (SCE) and the Food Service Technology Center (FSTC) conducted a field study to evaluate and compare energy savings and demand reduction potential between baseline and on-demand package sealers in supermarkets.[283] The study included four supermarket chains, with three sites selected for each chain. Each test site operated approximately 20 hours per day. Package sealers were located in deli, meat, and or produce departments. Power data was measured in 10-second intervals over a six-week monitoring period. A low sample interval was chosen to accurately capture the pulsing of the heating elements.

The study estimated demand savings by averaging power draw during the peak hours from 2-5 PM to account for the cycling of the larger heating element on the on-demand unit. This measure uses 10-minute average load shape to estimate coincidence factors consistent with the Texas peak definition.[284] This approach is more consistent with the 15-minute interval data typically used in calculated demand and energy charges by utilities. Demand savings are calculated by dividing energy savings by 8,760 and multiplying against the coincidence factor.

Deemed Energy and Demand Savings Tables

Table 158. Vacuum-Sealing & Packaging Machines—Deemed Energy and Demand Savings

Building Type	kWh/machine	Summer kW/ machine	Winter kW/ machine
Supermarkets, Grocery, & Food Stores	1,568	0.06	0.06

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for vacuum-sealing and packaging machines is 10 years, based on the University of California Useful Life Indices.[285]

283 "Vacuum-Sealing and Packaging Machines for Food Service Field Test, ET13SCE1190 Report," SCE & FTSC. December 2014. https://www.etcc-ca.com/reports/commerical-hand-wrap-machines-food-service-applications-field-test.

284 See Volume 1, Section 4.

285 "Useful Life Indices for Equipment Depreciation", University of California Office of the President. https://eulid.ucop.edu/.

Program Tracking Data and Evaluation Requirements

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

- Building type
- Number of packaging machines
- Packaging machine manufacturer and model

References and Efficiency Standards

Petitions and Rulings

None.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 159. Nonresidential Vacuum-Sealing & Packaging Machines Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.

2.5 NONRESIDENTIAL: REFRIGERATION

2.5.1 Door Heater Controls Measure Overview

TRM Measure ID: NR-RF-HC

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: Look-up tables

Savings Methodology: Engineering algorithms and estimates

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

The efficient equipment must be a standard-heat configuration door heater control utilized in an eligible commercial retail facility on glass-door refrigerated cases for the purpose of dynamically controlling humidity.

Baseline Condition

The 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 of 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 ($T_{d\text{-}out}$) per climate zone using the following equation:

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

Equation 115

The baseline assumes door heaters are running on an 8,760-hour operating schedule. 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 DP for a typical supermarket. Between these values, the door heaters' duty cycle changes proportionally:

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

Equation 116

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[286] at:

For medium temperature (coolers):

$$kW_{ASH} = 0.109\ per\ door\ or\ 0.0436\ per\ linear\ foot\ of\ door$$ [287]

Equation 117

For low temperature (freezers):

$$kW_{ASH} = 0.191\ per\ door\ or\ 0.0764\ per\ linear\ foot\ of\ door$$ [288]

Equation 118

---

[286] Pennsylvania TRM, "3.5.6 Controls. Anti-Sweat Heater Controls". page 381, Table 3-101. June 2016. http://www.puc.pa.gov/pcdocs/1350348.docx. Accessed 08/2020. Additional reference from Pennsylvania TRM: State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs Deemed Savings Manual. Table 4-75., March 22, 2010. https://focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf.

[287] Ibid.

[288] Ibid.

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 119

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

Equation 120

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,[289] the cooling load contribution from door heaters can be given by:

$$Q_{ASH}(ton - hrs) = 0.35 \times kW_{ASH} \times \frac{3{,}412 \frac{Btu}{hr}}{12{,}000 \frac{Btu}{ton}} \times Door\ Heater\ ON\%$$

Equation 121

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 of 1/1.15 or approximately 0.87.[290]

For medium temperature compressors, the following equation is used to determine the EER_{MT} [Btu/hr/watts], which are shown in Table 160.

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

Equation 122

Where:

a	=	*3.75346018700468*
b	=	*-0. 049642253137389*
c	=	*29.4589834935596*

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

[290] Work Paper PGEREF108: Anti-Sweat Heat (ASH) Controls. Pacific Gas and Electric Company. May 29,2009. Assumes 15% oversizing.

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	=	*1/1.15 = 0.87*
SCT	=	$T_{db} + 15$
T_{DB}	=	*Dry Bulb Temperature*

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 123

Where:

a	=	*9.86650982829017*
b	=	*-0.230356886617629*
c	=	*22.905553824974*
d	=	*0.00218892905109218*
e	=	*-2.48866737934442*
f	=	*-0.248051519588758*
g	=	$-7.57495453950879 \times 10^{-6}$
h	=	*2.03606248623924*
i	=	*-0.0214774331896676*
j	=	*0.000938305518020252*
PLR	=	*1/1.15 = 0.87*
SCT	=	$T_{db} + 10$
T_{DB}	=	*Dry Bulb Temperature*

Table 160. Coefficients by Climate Zone

Climate zone	Summer design T_{DB}[291]	SCT_{MT}	SCT_{LT}	EER_{MT}	EER_{LT}
Zone 1: Amarillo	96	111	106	6.44	4.98
Zone 2: Dallas	100	115	110	6.05	4.67
Zone 3: Houston	96	111	106	6.44	4.98
Zone 4: McAllen	100	115	110	6.05	4.67
Zone 5: El Paso	101	116	111	5.95	4.59

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 124

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

Equation 125

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 126

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

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

Equation 127

While there might be instantaneous demand savings because 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 128

Deemed Energy and Demand Savings Tables

The energy and demand savings of anti-sweat door heater controls are deemed values based on city/climate zone and refrigeration temperature. The following table provides these deemed values.

291 ASHRAE Climatic Region Data, 0.5% (°F).

Table 161. Deemed Energy and Demand Savings Values by Location and Refrigeration Temperature

Climate zone	Medium temperature		Low temperature	
	Annual energy savings (kWh/ft)	Peak demand savings (kW/ft)	Annual energy savings (kWh/ft)	Peak demand savings (kW/ft)
Zone 1: Amarillo	364	0.007	668	0.015
Zone 2: Dallas	249	0.005	457	0.011
Zone 3: Houston	180	0.003	330	0.007
Zone 4: McAllen	137	0.003	251	0.006
Zone 5: El Paso	405	0.008	745	0.018

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 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 per the PUCT approved Texas EUL filing (Docket No. 36779). It is also consistent with the DEER 2014 EUL update (EUL ID—GrocDisp-ASH). [292]

Program Tracking Data and 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.

- Climate zone
- Refrigeration temperature

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669—Provides energy and demand savings and measure specifications. Attachment A: https://interchange.puc.texas.gov/Documents/40669_7_736774.PDF. Accessed 11/13/2019. https://interchange.puc.texas.gov/Documents/40669_7_736775.PDF. Accessed 11/13/2019.

[292] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

- PUCT Docket 36779—Provides EUL for Anti-Sweat Heater Controls

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 162. Nonresidential Door Heater Controls Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. 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	TRM v2.1 update. Correction to state that savings are on a per-linear foot of display case.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. 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 122 and Equation 123.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.5.2 ECM Evaporator Fan Motors 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: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the replacement of existing evaporator fan motors with electronically commutated motors (ECMs) in cooler and freezer display cases. ECMs can provide up to 65 percent reduction in fan energy use with higher efficiencies, automatic variable-speed drive, lower motor operating temperatures, and less maintenance.

Eligibility Criteria

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

Baseline Condition

The 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 the 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 129

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

Equation 130

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

Equation 131

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

Equation 132

Freezer

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

Equation 133

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

Equation 134

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

Equation 135

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

Equation 136

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 coolers and 8,273*[293] *for walk-ins (see Table 163)*
%OFF	=	*The percentage of time that the evaporator fan motors are off. If the facility does not have evaporator fan controls %OFF = 0, and if the facility has evaporator fan controls %OFF = 46%.*[294]

[293] The Pennsylvania TRM, June 2016, utilizes the Efficiency Vermont source reproduced below this footnoted statement for an assumption of 8,273 hours for walk-in freezers. This is, furthermore, equivalent to stating the freezer's duty cycle is approximately 94.4% (8,273 / 8,760 ≈ 0.944), an assumed value which appears in **Error! Reference source not found.** for the $DC_{EvapFreezer}$ variable. T he Maine TRM, July 2019, details the derivation of 8,273 and thus approximately 94.4%: "A[n] evaporator fan in a cooler runs all the time, but a freezer runs only 8,273 hours per year due to defrost cycles (4 20-min defrost cycles per day)".

- Pennsylvania TRM, "3.5.3 High-Efficiency Fan Motors for Walk-In Refrigerated Cases". Page 369, Table 3-93. June 2016. http://www.puc.pa.gov/pcdocs/1350348.docx.
- 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.
- Efficiency Maine, Commercial/Industrial and Multifamily Technical Reference Manual 2020.1, July 1, 2019. Page 83, footnote 401.

[294] The Massachusetts Technical Reference Manual, 2012 Program Year – Plan Version, "Refrigeration – Evaporator Fan Controls", October 2011. Page 216, footnote 414 cites the following as the source for this variable:
"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."

Table 163. Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed values
W_{base}	See Table 164
W_{ee}	See Table 164
LF[295]	0.9
$DC_{EvapCool}$[296]	100%
$DC_{EvapFreeze}$[297]	94.4%
COP_{cooler}	See Table 165
$COP_{freezer}$	See Table 165
Hours[298]	8,760 or 8,273
%OFF	0 or 46%

Table 164. Motor Sizes, Efficiencies, and Input Watts[299]

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

295 The Pennsylvania TRM, June 2016, cites the following as the source for determining the load factor of the evaporator fan motor:
"ActOnEnergy; Business Program-Program Year 2, June 2009 through May 2010. Technical Reference Manual, No. 2009-01." Published 12/15/2009.
Pennsylvania TRM, "3.5.2 High-Efficiency Fan Motors for Reach-In Refrigerated Cases". page 365, Table 3-89. June 2016. http://www.puc.pa.gov/pcdocs/1350348.docx.

296 Efficiency Maine, Commercial/Industrial and Multifamily Technical Reference Manual 2020.1, July 1, 2019. Page 83, footnote 401.

297 See footnotes 293 and 296.

298 See footnote 293 for the explanation of the assumption of 8,273 for walk-in freezers.

299 The first three rows in this table are sourced from the Pennsylvania TRM, June 2016. Pennsylvania TRM, "3.5.2 High-Efficiency Fan Motors for Reach-In Refrigerated Cases". page 366, Table 3-90. June 2016. http://www.puc.pa.gov/pcdocs/1350348.docx.
The last two rows are estimated using logarithmic linear regression of smaller motor efficiencies.

Table 165. Compressor Coefficient of Performance Based on Climate and Refrigeration Type (COP_{cooler} or $COP_{freezer}$)

Representative climate city	Summer design dry bulb temperature[300]	COP_{cooler}	$COP_{freezer}$
Zone 1: Amarillo	98.6	1.88	1.46
Zone 2: Dallas	101.4	1.77	1.37
Zone 3: Houston	97.5	1.89	1.46
Zone 4: McAllen	96.8	1.77	1.37
Zone 5: El Paso	101.1	1.74	1.35

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 the motors have controls. Evaporator fan nameplate data, rated power, and efficiency is also required.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

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 and 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.

- Climate zone
- Building type
- Motor efficiency
- Motor power rating
- Evaporator fan control type
- Refrigeration temperature

[300] 2017 ASHRAE Handbook: Fundamentals, 0.4% summer design dry-bulb temperatures. http://ashrae-meteo.info/v2.0/.

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 166. Nonresidential ECM Evaporator Fan Motors Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. Updated the methodology with cooler and freezer values.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.5.3 Electronic Defrost 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 calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of electronic defrost controls. The controls sense whether a defrost cycle is required in a refrigerated case and skips it if it is unnecessary.

Eligibility Criteria

Not applicable.

Baseline Condition

The baseline efficiency case is a refrigerated case without defrost controls or with 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 the number of defrosts. The energy and demand savings are calculated using the following equations:

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

Equation 137

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

Equation 138

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

Equation 139

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

Equation 140

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; 3,412 Btuh/kW divided by 12,000 Btuh/ton*
Eff	=	*Estimated efficiency based on climate and refrigeration temperature (i.e., low temperature or medium temperature)*

Table 167. Deemed Variables for Energy and Demand Savings Calculations

Climate zone	DRF	Eff_{MT}[301]	Eff_{LT}[302]
Zone 1: Amarillo	35%	1.86	2.41
Zone 2: Dallas		1.98	2.57
Zone 3: Houston		1.86	2.41
Zone 4: Corpus Christi		1.98	2.57
Zone 5: El Paso		2.02	2.61

Deemed Energy and Demand Savings Tables

The energy and demand savings of Defrost Controls are calculated using a deemed algorithm based on climate zone and refrigeration temperature and are therefore not associated with deemed energy nor demand tables.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 10 years.[303]

Program Tracking Data and 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.

- Climate zone
- Hours that defrost occurs over a year without defrost controls
- Load of electric defrost
- Refrigeration temperature (low temperature or medium temperature)

[301] Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.o.2007).
[302] Ibid.
[303] Energy and 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

Not applicable.

Document Revision History

Table 168. Nonresidential Electronic Defrost Controls Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

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: Engineering algorithms and estimates

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

Not applicable.

Baseline Condition

The 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 the 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 the operation of the fan. The energy and demand savings are calculated using the following equations:

$$Energy\ [kWh] = \Delta kW \times 8{,}760$$

Equation 141

$$Peak\ Demand\ [kW] = \left(\left(kW_{evap} \times n_{fans} \right) - kW_{circ} \right) \times \left(1 - DC_{comp} \right) \times DC_{evap} \times BF$$

Equation 142

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*
8,760	=	*Annual hours per year*

Table 169. Deemed Variables for Energy and Demand Savings Calculations[304]

Variable	Deemed values
kW_{evap}	0.123 kW
kW_{circ}	0.035 kW
DC_{comp}	50%
DC_{evap}	Cooler: 100% Freezer: 94.4%
BF	Low Temp: 1.5 Medium Temp: 1.3 High Temp: 1.2

Deemed Energy and Demand Savings Tables

Not applicable.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

---

[304] The Maine Technical Reference Manual was utilized to determine all of these assumed values. Efficiency Maine, Commercial/Industrial and Multifamily Technical Reference Manual 2020.1, July 1, 2019.

- kW_{evap} Page 78, footnote 366 states this value is determined "based on a weighted average of 80% shaded-pole motors at 132 watts and 20% PSC motors at 88 watts. This weighted average is based on discussions with refrigeration contractors and is considered conservative (market penetration estimated at approximately 10%)."
- kW_{circ}: Page 78, footnote 367 states this value is the "wattage of fan used by Freeaire and Cooltrol"
- DC_{comp}: Page 78, footnote 368 states the reasoning for this value as follows: "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 and 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."
- DC_{evap}: 94.4% is equivalent to 8,273 / 8,760 annual operating hours. The assumption of 8,273 is the annual total of the assumption that "a[n] evaporator fan in a cooler runs all the time, but a freezer only runs 8,273 hours per year due to defrost cycles (4 20-min defrost cycles per day)", an explanation given on page 82, footnote 401.
- BF: Page 183, Table 45, footnote A summarizes the Bonus Factor (-1 + 1/COP) as "assum[ing] 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."

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).[305]

Program Tracking Data and 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

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 170. Nonresidential Evaporator Fan Controls Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

[305] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

2.5.5 Night Covers for Open Refrigerated Display Cases Measure Overview

TRM Measure ID: NR-RF-NC

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: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of night covers on the otherwise open vertical (multi-deck) and horizontal (or coffin-type) low-temperature and medium-temperature display cases to decrease the 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 Condition

The 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[306] per day (i.e., continuous overnight use). Vertical strip curtains may be in use 24 hours per day.

[306] Faramarzi, R. "Practical Guide: Efficient Display Case Refrigeration", 1999 ASHRAE Journal, Vol. 41, November 1999.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The following outlines the assumptions and approach used to estimate demand and energy savings resulting from the 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. The calculations assume that installing night covers on open display cases will only reduce the infiltration load on the case. At 75 °F dry bulb temperature and 55% relative humidity, infiltration affects cooling load in the following ways:

- Infiltration accounts for approximately 80 percent of the total cooling load of open vertical (or multi-deck) display cases.[307]
- Infiltration accounts for approximately 24 percent of the total cooling load of open horizontal (coffin or tub style) display cases.[308]

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

- 8% on vertical cases cases (and furthermore reduce the compressor power requirement by 9%)[309]
- 50% on horizontal cases.[310]

The energy savings due to the reduced infiltration load when night covers are installed will vary based on the 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.

---

307 ASHRAE 2018. Refrigeration Handbook. Retail Food Store Refrigeration and Equipment. Atlanta, Georgia. p. 15.6.

308 Ibid.

309 Ibid., p. 15.26.

310 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.

Once the infiltration load for each type of case is determined, the following steps are taken 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, though, is limited to the cooling load imposed by convection (infiltration) only and not the total cooling load of a particulate display case.

- 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:

$$Q_{baselineInfiltration}[ton-hours] = \frac{Q_{baselineInfiltration}[Btuh] \times Bin-hours}{12{,}000 \left[\frac{Btu}{ton}\right]}$$

Equation 143

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

- Determine the saturated condensing temperature (SCT)

For medium temperature (MT):

$$SCT = T_{DB} + 15$$

Equation 144

For low temperature (LT):

$$SCT = T_{DB} + 10$$

Equation 145

Where:

T_{DB} = *Summer design dry-bulb temperature (°F), based on climate zone, of ambient or space where the compressor/condensing units reside. Table 171 lists these summer design dry-bulb temperatures by climate zone.*

Table 171. Summer Design Dry Bulb Temperaturesby Climate Zone

Climate zone	T_{DB} (°F)[311]
Zone 1: Amarillo	96
Zone 2: Dallas	100
Zone 3: Houston	96
Zone 4: McAllen	100
Zone 5: El Paso	101

- Determine the EER for both medium temperature and low temperature applications.

[311] ASHRAE 2009 Handbook Fundamentals.

- 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.[312]
- Part-load ratio (PLR) is the ratio of total cooling load 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 146

Where:

PLR	=	*Part load ratio*
Qcooling	=	*Cooling load*
Qcapacity	=	*Total compressor capacity*[313]

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

Equation 147

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

Equation 148

To simplify the analysis, it is assumed that PLR remains constant at 1/1.15 for the post-retrofit condition.[314]

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, and a PLR of 0.87.

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

Equation 149

312 Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.0.2007).

313 Compressor capacity is determined by multiplying baseline cooling load by a compressor over-sizing factor of 15 percent.

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

Where:

a	=	*3.75346018700468*
b	=	*-0.049642253137389*
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*

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).

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

Equation 150

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*

Convert EER to kW/ton

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

Equation 151

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 152

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

$$kWh_{baseline\_refrig} = \sum kWh_{baseline\_refrig\_bin}$$

Equation 153

In the post-retrofit case, it is assumed that night covers are installed on the cases during the nights from midnight to 6:00 AM. During the day, the cases are uncovered and the total cooling load for each bin can be given by:

$$Q_{post\_Retrofit}[ton\_hours] = \frac{Q_{baseline\_Infiltration}\,[Btuh] \times Daytime_{bin\_hrs}}{12{,}000\,\left[\frac{Btuh}{ton}\right]} + \frac{(Q_{baseline\_Infiltration}\,[Btuh] - Q_{reduced\_infiltration}\,[Btuh]) \times Nighttime_{bin\_hrs}}{12{,}000\,\left[\frac{Btuh}{ton}\right]}$$

Equation 154

These steps are repeated in the post-retrofit case to calculate the post-retrofit energy and demand usage.

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 155

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, Texas) was chosen to represent the entire state.[315] The deemed energy and demand savings are shown below.

[315] 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.

Table 172. 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-temperature Cases	45	0
Night Covers on Horizontal Low-temperature Cases	23	0
Night Covers on Vertical Medium-temperature Cases	35	0
Night Covers on Horizontal Medium-temperature Cases	17	0

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

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).[316]

Program Tracking Data and 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 : https://interchange.puc.texas.gov/Documents/40669_7_736774.PDF. Accessed 11/13/2019.

Relevant Standards and Reference Sources

- DEER 2014 EUL update

[316] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

Document Revision History

Table 173. Nonresidential Night Covers for Open Refrigerated Display Cases Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. 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	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. Added more significant digits to the input variables a-j for Equation 149 and Equation 150.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

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: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of ENERGY STAR® or CEE certified solid and glass door reach-in refrigerators and freezers, which are significantly more efficient than non- ENERGY STAR® units. The high-efficiency criteria, developed by ENERGY STAR®, relate the volume of the appliance in cubic feet to its daily energy consumption.

Eligibility Criteria

Solid- or glass-door reach-in vertical refrigerators and freezers must meet ENERGY STAR® minimum efficiency requirements (See Table 175).

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

- Residential refrigerators and freezers
- Chef base or griddle stands, prep tables, service over counter equipment, horizontal open equipment, vertical open equipment, semi-vertical open equipment, remote condensing equipment, convertible temperature equipment, and ice cream freezers

Baseline Condition

The baseline efficiency case is a regular vertical 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 174.

Table 174. Baseline Energy Consumption[317,318]

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 ENERGY STAR® minimum efficiency requirements, as shown in Table 175.

Table 175. Efficient Energy Consumption Requirements[319]

Door type	Product volume (cubic feet)	Refrigerator daily consumption (kWh)	Freezer daily consumption (kWh)
Vertical Solid Door	0 < V < 15	0.022V + 0.97	0.21V + 0.9
	15 ≤ V < 30	0.066V + 0.31	0.12V + 2.248
	30 ≤ V < 50	0.04V + 1.09	0.285V - 2.703
	V ≥ 50	0.024V + 1.89	0.142V + 4.445
Vertical Glass Door	0 < V < 15	0.095V + 0.445	0.232V + 2.36
	15 ≤ V < 30	0.05V + 1.12	
	30 ≤ V < 50	0.076V + 0.34	
	V ≥ 50	0.105V - 1.111	

317 https://www.ecfr.gov/cgi-bin/text-idx?SID=ea9937006535237ca30dfd3e03ebaff2&mc=true&node=se10.3.431_166&rgn=div8.

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

319 ENERGY STAR® Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency. Accessed on 08/2020. https://www.energystar.gov/sites/default/files/Commercial%20Refrigerators%20and%20Freezers%20V4%20Spec%20Final%20Version_0.pdf.

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 174 and Table 175, based on the volume of the units.

The savings calculations are specified as:

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

Equation 156

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{8{,}760} \times CF$$

Equation 157

Where:

kWh_{base}	=	*Baseline maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 174.*
kWh_{ee}	=	*Efficient maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 175.*
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*
8,760	=	*Hours per year*
CF	=	*Summer peak coincidence factor (1.0)*[320]

[320] 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.

Deemed Energy and Demand Savings Tables

Table 176. Deemed Energy and Demand Savings

Refrigerator or freezer	Door type	Product volume range (cubic feet)	Average product volume	Energy savings (kWh)	Demand savings (kW)
Refrigerator	Vertical Solid Door	0 < V < 15	8.54	16	0.002
		15 ≤ V < 30	21.00	892	0.102
		30 ≤ V < 50	41.53	1,256	0.143
		V ≥ 50	67.19	1,919	0.219
	Vertical Glass Door	0 < V < 15	8.84	1,137	0.130
		15 ≤ V < 30	21.30	1,355	0.155
		30 ≤ V < 50	42.76	1,782	0.203
		V ≥ 50	68.93	2,002	0.229
Freezer	Vertical Solid Door	0 < V < 15	7.76	713	0.081
		15 ≤ V < 30	19.99	1,726	0.197
		30 ≤ V < 50	43.13	3,301	0.377
		V ≥ 50	66.86	5,177	0.591
	Vertical Glass Door	0 < V < 15	5.98	1,766	0.202
		15 ≤ V < 30	19.49	4,321	0.493
		30 ≤ V < 50	42.29	8,630	0.985
		V ≥ 50	65.89	13,093	1.495

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 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, per the PUCT Texas EUL filing (Docket No. 36779). This is consistent with the 2014 DEER EUL update.[321]

[321] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

Program Tracking Data and 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 and 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 177. Nonresidential Solid and Glass Door Reach-Ins Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

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: Look-up tables

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

The baseline efficiency case is a refrigerated walk-in space with nothing to impede airflow 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 if 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 178.

Table 178. Deemed Energy and Demand Savings for Freezers and Coolers[322]

Savings	Energy (kWh)	Demand (kW)
Coolers	422	0.05
Freezers	2,974	0.35

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

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).[323]

Program Tracking Data and 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)

[322] 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.

[323] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 provides energy and demand savings and measure specifications
- PUCT Docket 36779 provides EUL estimates for commercial refrigerators and freezers

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 179. Nonresidential Strip Curtains for Walk-In Refrigerated Storage Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

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, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and 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

The 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 of eliminating the heater (kWhASH) and the reduction in load on the refrigeration (kWhrefrig). These savings are calculated using the following procedures.

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

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

For medium temperature:

$$kW_{Ash} = 0.109\ per\ door\ or\ 0.0436\ per\ linear\ foot\ of\ door$$ [324]

For low temperature:

$$kW_{Ash} = 0.191\ per\ door\ or\ 0.0764\ per\ linear\ foot\ of\ door$$ [325]

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 158

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

Equation 159

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,[326] the cooling load contribution from door heaters can be given by:

[324] Here, "medium temperature" is equivalent to the categorization "coolers".
(Pennsylvania TRM) State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs Deemed Savings Manual. Table 4-75. March 22, 2010. https://focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf.
This prior source appears to have furthermore been sourced from the Pennsylvania TRM, June 2016, which states that "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."
Pennsylvania TRM, "3.5.6 Controls: Anti-Sweat Heater Controls". page 383, June 2016. http://www.puc.pa.gov/pcdocs/1350348.docx. Accessed 08/2020.

[325] Ibid. Here, "low temperature" is equivalent to the categorization "freezers".

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

$$Q_{ASH}(ton - hrs) = 0.35 \times kW_{ASH} \times \frac{3{,}412 \frac{Btu}{hr}}{12{,}000 \frac{Btu}{ton}} \times Door\ Heater\ ON\%$$

Equation 160

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 or 1/1.15 or approximately 0.87.[327]

For medium temperature compressors, the following equation is used to determine the EER_{MT} [Btu/hr/watts]. These values are shown in Table 160.

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

Equation 161

Where:

a	=	*3.75346018700468*
b	=	*-0.0496422531373890*
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	=	*$T_{DB} + 15$*

327 *Work Paper PGEREF108: Anti-Sweat Heat (ASH) Controls.* Pacific Gas and Electric Company. May 29, 2009. Assumes 15% oversizing.

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 162

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	=	$T_{DB} + 10$

Table 180. Coefficients by Climate Zone

Climate zone	T_{DB}[328]	$T_{d\text{-}out}$[329]	SCT_{MT}	SCT_{LT}	EER_{MT}	EER_{LT}
Zone 1: Amarillo	98.6	67.2	113.6	108.6	6.18	4.74
Zone 2: Dallas	101.4	75.4	116.4	111.4	5.91	4.56
Zone 3: Houston	97.5	78.0	112.5	107.5	6.29	4.86
Zone 4: Corpus Christi	96.8	79.1	111.8	106.8	6.36	4.91
Zone 5: El Paso	101.1	66.3	116.1	111.1	5.94	4.58

Where:

T_{DB}	=	*Dry Bulb Temperature*
T_{d-out}	=	*Outdoor Dew Point*

[328] 2017 ASHRAE Handbook: Fundamentals, 0.4% summer design dry-bulb temperatures. http://ashrae-meteo.info/v2.0/.
[329] Ibid., 0.4% DP

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 163

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

Equation 164

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 165

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

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

Equation 166

While there might be instantaneous demand savings because 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:

$$Peak\ Demand\ Savings = \frac{kWh_{refrig-baseline} - kWh_{refrig-post}}{8{,}760}$$

Equation 167

Table 181. Deemed Energy and Demand Savings Values by Climate Zone and Refrigeration Temperature

Climate zone	Medium temperature		Low temperature	
	Annual energy savings (kWh/ft)	Peak demand savings (kW/ft)	Annual energy savings (kWh/ft)	Peak demand savings (kW/ft)
Zone 1: Amarillo	1,139	0.130	2,092	0.239
Zone 2: Dallas	1,148	0.131	2,111	0.241
Zone 3: Houston	1,136	0.130	2,084	0.238
Zone 4: Corpus Christi	1,134	0.129	2,080	0.237
Zone 5: El Paso	1,147	0.131	2,109	0.241

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 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 per the PUCT approved Texas EUL filing (Docket No. 36779) and the DEER 2014 EUL update (EUL ID—GrocDisp-ZeroHtDrs).[330]

Program Tracking Data and 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 182. Nonresidential Zero-Energy Doors for Refrigerated Cases Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. Updated savings methodology to be consistent with the door heater controls measure.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/20220	TRM v8.0 update. General reference checks and text edits.

[330] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

2.5.9 Door Gaskets for Walk-In and Reach-In Coolers and Freezers Measure Overview

TRM Measure ID: NR-RF-DG

Market Sector: Commercial

Measure Category: Refrigeration

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

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: M&V, engineering algorithms, and estimates

Measure Description

This measure applies to the installation of door gaskets on walk-in and reach-in coolers and freezers to reduce the refrigeration load associated with the infiltration of non-refrigerated air into the refrigerated space. Additionally, the reduction in moisture entering the refrigerated space also helps prevent frost on the cooling coils. Frost build-up adversely impacts the coil's heat transfer effectiveness, reduces air passage (lowering heat transfer efficiency), and increases energy use during the defrost cycle. Therefore, replacing defective door gaskets reduces compressor run time, reducing energy consumption and improving the overall effectiveness of heat removal from a refrigerated cabinet.

Eligibility Criteria

Door gaskets must be installed on walk-in and reach-in coolers or freezers. The most common applications for this measure are refrigerated coolers or freezers in supermarkets, convenience stores, restaurants, and refrigerated warehouses.

Baseline Condition

The baseline standard for this measure is a walk-in or reach-in cooler or freezer with worn-out, defective door gaskets. An average baseline gasket efficacy[331] of 90 percent is assumed for this measure.

[331] Gasket efficacy is defined as the ratio of the gasket length that was removed by the installers to the gasket length that was replaced. A 90 percent gasket efficacy translates to an average of 10 percent of missing, badly damaged or ineffective gasket by length replaced.

High-Efficiency Condition

The efficient condition for this measure is a new, better-fitting gasket. Tight fitting gaskets inhibit infiltration of warm, moist air into the cold refrigerated space, reducing the cooling load. A decrease in moisture entering the refrigerated space also prevents frost on cooling coils.

Energy and Demand Savings Methodology

The energy savings assumptions are based on DEER 2005 analysis performed by Southern California Edison (SCE) and an evaluation of a Pacific Gas and Electric (PG&E) direct install refrigeration measures for program year 2006-2008.[332,333] The results from the PG&E evaluation were used as the foundation for establishing the energy savings for the refrigeration gasket measures. The energy savings achievable for new gaskets replacing baseline gaskets were found during this study to be dependent almost entirely on the leakage through the baseline gaskets. Therefore, the energy savings attributable to door gaskets were derived for various scenarios regarding baseline gasket efficacies and are shown in Table 183 below.

Table 183. Energy Savings Achievable for New Gaskets Replacing Baseline Gaskets of Various Efficacies (per Linear Foot of Installed Door Gasket)[334]

Refrigerator type	Baseline 0% efficacy (kWh/ft)	Baseline 50% efficacy (kWh/ft)	Baseline 90% efficacy (kWh/ft)	Baseline 100% efficacy (kWh/ft)
Cooler	30	15	3	0
Freezer	228	114	23	0

As the PG&E analysis was performed in California with different climate zones as compared to those in Texas, an analysis was conducted to develop an adjustment factor to associate the savings in the table above to Texas anticipated results. The PG&E study could not be used to determine these effects, as insufficient climate zones were researched. Therefore, the SCE study was utilized as savings in this study were determined for each of the 16 climate zones in California and were similar[335] to those assessed within the PG&E results at 90 percent efficacy. A comparison was completed between the SCE energy savings and the typical meteorological year 3 (TMY3) data[336] to establish a cooling degree day (CDD) correlation across the 16 California climate zones. Figure 3 provides a summary comparison for coolers and Figure 4 for freezers.

---

332 Southern California Edison (SCE). WPSCNRRN0013—Door Gaskets for Glass Doors of Medium and Low Temperature Reach-in Display Cases and Solid Doors of Reach-in Coolers and Freezers. 2007.

333 Commercial Facilities Contract Group (ComFac), 2006-2008 Direct Impact Evaluation Study ID: PUC0016.01. February 18, 2010. https://energy.mo.gov/sites/energy/files/comfac_evaluation_v1_final_report_02-18-2010.pdf.

334 Ibid., Table 5-3.

335 The SCE ex-ante savings as reported in the PG&E report were 10.2 and 21.7 kWh/linear foot for coolers and freezers respectively.
Commercial Facilities Contract Group (ComFac), 2006-2008 Direct Impact Evaluation Study ID: PUC0016.01. February 18, 2010. Table 5-3.
https://energy.mo.gov/sites/energy/files/comfac_evaluation_v1_final_report_02-18-2010.pdf.
Modeled savings as reported in the SEC report for climate zone 4 were approximately 6 and 15 kWh/linear foot for coolers and freezers respectively.

336 https://gds-files.nrelcloud.org/rredc/1991-2005.zip

The resulting correlations are strong, with an R^2 of 0.85 for coolers and an R^2 of 0.88 for freezers, respectively.

Figure 3. Comparison of Projected Annual Energy Savings to Cooling Degree Days for All 16 California Climate Zones for Reach-In Display Cases (Coolers)

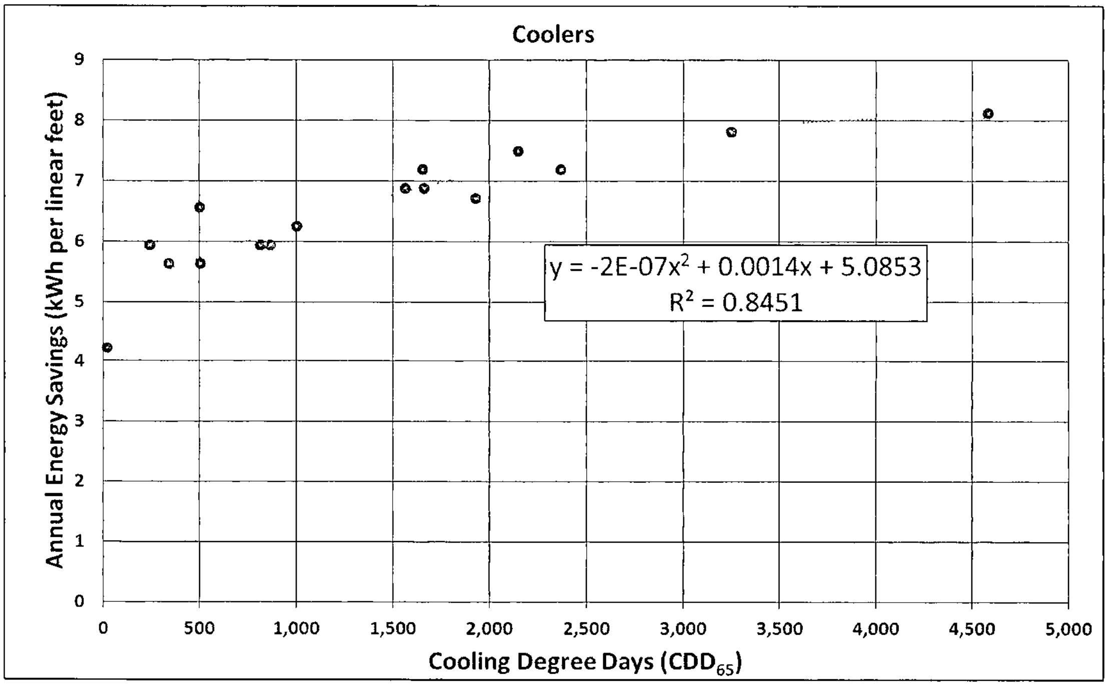
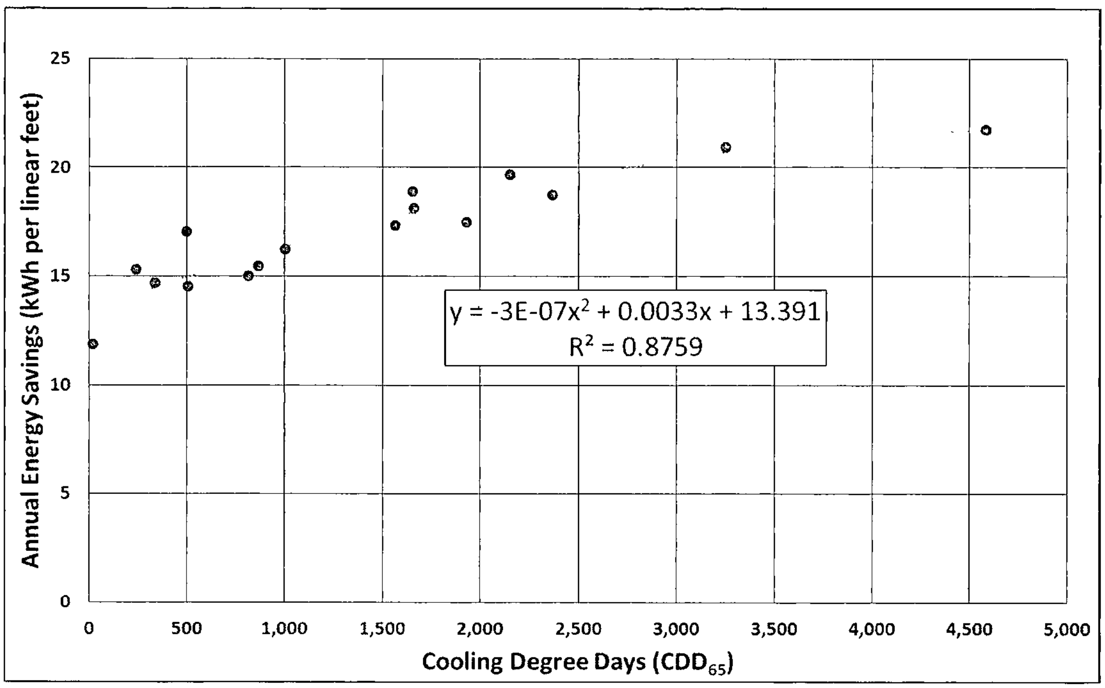


Figure 4. Comparison of Projected Annual Energy Savings to Cooling Degree Days for All 16 California Climate Zones for Reach-In Display Cases (Freezers)



These correlations were used to adjust the energy savings and TMY3 CDDs in California to TMY3 CDDs in Texas to determine an average energy savings of 7.4 and 20.0 kWh/linear feet for coolers and freezers in Texas. Comparing the average energy savings between California and Texas, the CDD adjustment results in a 113 percent adjustment factor for coolers and a 117 percent adjustment factor for freezers. For simplicity, an average adjustment factor of 115 percent (the midpoint of 113% and 117% TX vs. CA Energy Savings values) was applied to the PG&E results at 90 percent efficacy (as shown in Table 183 above), resulting in Texas-based annual energy savings values for coolers of 3.5 kWh/linear feet and freezers of 26.5 kWh/linear feet. These results are summarized in Table 184 below.

Table 184. Energy Savings Achievable for New Gaskets Replacing Baseline Gaskets of Various Efficacies (per Linear Foot of Installed Door Gasket)

Refrigerator type	CA CZ1-CZ16 average savings (kWh/ft)	CA average savings normalized to TX by CDD (kWh/ft)	TX vs. CA energy savings	Average CDD adjustment factor	PG&E baseline 90% efficacy (kWh/ft)	TX baseline 90% efficacy (kWh/ft)
Cooler	6.5	7.4	113%	115%	3	3.5
Freezer	17.1	20.0	117%		23	26.5

Because the walk-in or reach-in cooler or freezer is kept at a constant temperature, the demand savings are estimated as the total energy savings divided evenly over the full year (8,760 hours).

Savings Algorithms and Input Variables

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

$$Energy\ Savings\ [kWh] = \frac{\Delta kWh}{ft} \times L$$

Equation 168

$$Demand\ Savings\ [kW] = \frac{kWh_{Savings}}{8760} \times L$$

Equation 169

Where:

ΔkWh/ft = *Annual energy savings per linear foot of gasket (see Table 185)*

L = *Total gasket length (ft)*

Deemed Energy and Demand Savings Tables

Table 185. Deemed Energy and Demand Savings per Linear Foot of Installed Door Gasket

Refrigerator type	ΔkW/ft	ΔkWh/ft
Walk-in or Reach-in Cooler	0.0004	3.5
Walk-in or Reach-in Freezer	0.0030	26.5

Claimed Peak Demand Savings

Because the walk-in or reach-in cooler or freezer is kept at a constant temperature, the demand savings are estimated as the total energy savings divided evenly over the full year (8,760 hours).

Measure Life and Lifetime Savings

The EUL for this measure is 4 years, according to the California Database of Energy Efficiency Resources (EUL ID – GrocDisp-FixtDrGask).[337]

Program Tracking Data and Evaluation Requirements

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

- Building type (convenience store, supermarket, restaurant, refrigerated warehouse)
- Refrigerator type (walk-in or reach-in cooler or freezer)
- Total length of installed gasket (ft.)
- Presence of existing gasket (yes/no)
- Optional (if applicable): length of ineffective baseline gasket (feet), general description of baseline gasket condition (e.g., good, moderate, poor, non-existent), and primary reason for baseline gasket ineffectiveness (partial tear, torn and dislocated, rotted/dry, poor fit/shrink, missing, or other)

References and Efficiency Standards

Petitions and Rulings

- Docket No. 48265. Petition of AEP Texas Inc., CenterPoint Energy Houston Electric, LLC, El Paso Electric Company, Entergy Texas, Inc., Oncor Electric Delivery Company LLC, Southwestern Electric Power Company, Southwestern Public Service Company, and Texas-New Mexico Power Company. *Petition to Approve Deemed Savings for New Nonresidential Door Air Infiltration, Nonresidential Door Gaskets, And Residential ENERGY STAR® Connected Thermostats.* Public Utility Commission of Texas.

Relevant Standards and Reference Sources

Not applicable.

[337] Database for Energy Efficient Resources, EUL Table Update, February 5, 2014. Accessed 08/2020. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

Document Revision History

Table 186. Nonresidential Door Gaskets for Walk-In and Reach-In Coolers and Freezers Revision History

TRM version	Date	Description of change
v6.0	10/2018	TRM v6.0 origin.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.5.10 High Speed Doors for Cold Storage Measure Overview

TRM Measure ID: NR-RF-HS

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Algorithms

Savings Methodology: Algorithms

Measure Description

This measure presents deemed savings for installation of high speed doors for cold storage facilities. High speed automatic doors differ from regular automatic doors by increasing their closing speed. High speed doors can save energy over regular automatic and manual doors by shortening the duration that the door to the cold storage area is open.

Eligibility Criteria

Eligible equipment includes high speed doors with a minimum opening rate of 32 inches per second, a minimum closing rate of 24 inches per second, and a means to automatically reclose the door, as defined by the Door and Access Systems Manufacturers' Association, International (DASMA).[338] The high speed doors must be installed for access to a cold storage area either from exterior conditions, such as a loading dock, or from a conditioned area, such as a non-refrigerated warehouse.

Baseline Condition

The baseline condition is a manual or non-high speed automatic door installed for access to a cold storage area.

High-Efficiency Condition

The efficient condition is a high speed door installed for access to a cold storage area.

[338] DASMA Standard Specification for High Speed Doors and Grilles, definition 2.6 for High Speed Door. https://www.dasma.com/PDF/Publications/standards/DASMA403.pdf. Accessed August 2020.

Energy and Demand Savings Methodology

Savings are calculated based on a reduction in heat gain from airflow across the door opening area. The algorithms below are modeled after equations 14 and 16 in Chapter 24: Refrigerated-Facility Loads of the 2018 ASHRAE Handbook—Refrigeration to calculate heat load associated with infiltration air exchange. This measure does not account for associated motor load or efficiencies; if the new high speed door includes an efficient motor, reference the motor measure for savings.

Savings Algorithms and Input Variables

$$\text{kWh savings} = \frac{w \times h^{1.5} \times energy\ factor}{COP \times 3{,}412}$$

Equation 170

$$\text{energy factor} = hours \times 3{,}790 \times \frac{q_s}{A} \times \frac{1}{R_s} \times \Delta D_t \times D_f \times \Delta E$$

Equation 171

$$\text{kW savings} = \frac{w \times h^{1.5} \times demand\ factor}{COP \times 3{,}412}$$

Equation 172

$$\text{demand factor} = 3{,}790 \times \frac{q_s}{A} \times \frac{1}{R_s} \times \Delta D_t \times D_f \times \Delta E$$

Equation 173

Where:

w	=	*width of the door opening, ft*
h	=	*height of the door opening, ft*
$energy\ factor$	=	*the outcome of Equation 178 based on climate zone and cold storage application, see Table 187, and Table 188*
$demand\ factor$	=	*the outcome of Equation 180 based on climate zone and cold storage application, see Table 189, Table 190, and Table 191*
$hours$	=	*operating hours, 3,798*[339]
3,790	=	*constant*[340]

[339] Operating hours taken from TRM Volume 3, Table 8, hours for refrigerated warehouse.
[340] From ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, equation 16.

$\frac{q_s}{A}$ = *sensible heat load of infiltration air per square foot of door opening, ton/ft², see Table 192*

R_s = *Sensible heat ratio of the infiltration air heat gain, see Table 193*

ΔD_t = *change in percent of time the doorway is open, 0.33*[341]

D_f = *Doorway flow factor, varies based on Temperature delta between cold room and infiltration air, 0.8 for delta T ≥ 20°F, 1.1 for delta T < 20°F*[342]

ΔE = *change in door effectiveness, 0.2*[343]

COP = *coefficient of performance, assume 2.8 COP*[344]

$3{,}412$ = *conversion factors*

Table 187. High Speed Doors—Energy Factors for Door to Unconditioned Area

Cold room temperature	-20°F	0°F	20°F	40°F
Zone 1: Amarillo	849,911	76,602	324,007	122,795
Zone 2: Dallas	1,025,489	719,712	432,092	209,695
Zone 3: Houston	1,179,743	837,151	562,418	420,336
Zone 4: Corpus Christi	1,240,984	887,904	603,598	464,913
Zone 5: El Paso	902,050	614,930	343,300	142,285

Table 188. High Speed Doors—Energy Factors for Door to Conditioned Area

Cold room temperature	-20°F	0°F	20°F	40°F
All Climate Zones	783,056	518,199	322,435	230,311

Table 189. High Speed Doors—Summer and Winter Demand Factors for Door to Conditioned Area

Cold room temperature	All temperatures
All Climate Zones	1.0

341 From ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, simplification of equation 17 notes; assume baseline door open-close time is 15 seconds, and high speed door open-close time is 10 seconds, for a difference in percent of time the door is open of (15-10)/15 = 0.33.

342 ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, equation 17 notes.

343 ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, simplification of equation 17 notes. ASHRAE provides a range of doorway effectiveness, stating 0.95 for newly installed doors though that may quickly decrease to 0.8 or 0.85 depending on door use frequency and maintenance. Air curtain effectiveness ranges from very poor to more than 0.7. The input assumptions for this measure are conservatively estimated for baseline door effectiveness of 0.7 and high speed door effectiveness of 0.9.

344 Air cooled chiller efficiency from IECC 2009.

Table 190. High Speed Doors—Summer Demand Factors for Door to Unconditioned Area

Cold room temperature	-20°F	0°F	20°F	40°F
Zone 1: Amarillo	278.94	208.20	141.49	90.96
Zone 2: Dallas	293.09	218.30	153.62	101.07
Zone 3: Houston	293.09	218.30	153.62	101.07
Zone 4: Corpus Christi	264.79	192.03	131.39	76.81
Zone 5: El Paso	278.94	208.20	141.49	90.96

Table 191. High Speed Doors—Winter Demand Factors for Door to Unconditioned Area

Cold room temperature	-20°F	0°F	20°F	40°F
Zone 1: Amarillo	40.43	-	-	-
Zone 2: Dallas	40.43	-	-	-
Zone 3: Houston	80.85	36.38	22.23	-
Zone 4: Corpus Christi	80.85	36.38	22.23	-
Zone 5: El Paso	80.85	36.38	-	-

Table 192. High Speed Doors—$\frac{q_s}{A}$, Sensible Heat Load of Infiltration Air[345]

	Applicable climate zones							
	Z1-2, winter peak	Z3-5, winter peak	Z1, annual	Z2, Z5, annual	Z3-4, annual	Z4, summer peak	Z1, Z5, summer peak	Z2-3, summer peak
	Infiltration air temperature							
Cold room temperature	15°F	30°F	63°F	70°F	75°F	96°F	99°F	103°F
-20°F	0.2	0.40	0.85	0.94	1.02	1.31	1.38	1.45
0°F	-	0.18	0.55	0.62	0.68	0.95	1.03	1.08
20°F	-	0.08	0.30	0.35	0.42	0.65	0.70	0.76
40°F	-	-	0.13	0.17	0.30	0.38	0.45	0.50

345 From ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, figure 9. Values in table are summarized to reflect average annual and summer and winter peak infiltration air Temperatures. Where infiltration air Temperatures are not shown on ASHRAE figure 9, $\frac{q_s}{A}$ is estimated by extrapolation. Values for infiltration air temperature of 75°F are used to calculate energy and demand factors for doorways between cold room and conditioned space.

Table 193. High Speed Doors—R_S, Sensible Heat Ratio of Infiltration Air[346]

Applicable climate zones	For energy factor, unconditioned space				For energy factor, conditioned space	For demand factor, conditioned and unconditioned space	
	Cold room temperature						
	-20°F	0°F	20°F	40°F	All temps	Summer, all temps	Winter, all temps
Zone 1: Amarillo	0.77	0.73	0.71	0.81	1.0	1.0	1.0
Zone 2: Dallas	0.70	0.66	0.62	0.62			
Zone 3: Houston	0.66	0.62	0.57	0.55			
Zone 4: Corpus Christi	0.63	0.58	0.53	0.50			
Zone 5: El Paso	0.80	0.77	0.78	0.92			

Deemed Energy and Demand Savings Tables

There are no deemed savings tables for this measure. Please refer to the savings algorithms above.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for this measure is 5 years based on published manufacturer warranty duration.

[346] Sensible heat ratio determined from psychrometric chart, using values for the air properties of dry bulb Temperature and relative humidity. Relative humidity of the cold room is estimated at 90% based on ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, Table 9. Energy factor values for unconditioned space are the average annual values between the expected operating hours of 8am – 6pm using TMY3 data. Demand factor values for unconditioned space are taken using the highest probability Temperatures from TRM Volume 1 and their associated relative humidity from TMY3 data. Energy and demand factor values for conditioned space assume conditioned air temperature of 75°F and 45% RH.

Program Tracking Data and 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.

- Climate zone
- Cold room temperature
- Doorway opening location – conditioned or unconditioned
- Width and height of door

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 194. Nonresidential High Speed Doors for Cold Storage Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.

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: Look-up tables

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

Not applicable.

Baseline Condition

Eligible baseline equipment is a 120-volt single phase refrigerated beverage or non-refrigerated snack vending machine. Refrigerated beverage vending machines manufactured and purchased prior to August 31, 2012. Refrigerated beverage vending machines manufactured after this date must already comply with federal standard maximum daily energy consumption requirements. The current federal standard further reduced these maximum consumption values, effective January 8, 2019.[347]

[347] Appliance Standards for Refrigerated Beverage Vending Machines. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=29#current_standards.

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

Not applicable.

Deemed Energy and Demand Savings Tables

Energy and demand savings for different sized vending machines are deemed values, pieced together from different sources and studies, outlined in the following tables.

Table 195. Vending Machine Controls—Refrigerated Cold Drink Unit Deemed Savings[348]

Climate zone	kWh savings	Summer kW savings[349]	Winter kW savings
Zone 1: Amarillo	1,612	0.023	0.060
Zone 2: Dallas		0.021	0.063
Zone 3: Houston		0.022	0.060
Zone 4: Corpus Christi		0.022	0.064
Zone 5: El Paso		0.015	0.068

Table 196. Vending Machine Controls—Refrigerated Reach-In Unit Deemed Savings[350]

Climate zone	kWh savings	Summer kW savings	Winter kW savings
Zone 1: Amarillo	1,086	0.026	0.069
Zone 2: Dallas		0.024	0.073
Zone 3: Houston		0.026	0.068
Zone 4: Corpus Christi		0.026	0.074
Zone 5: El Paso		0.017	0.078

348 Pacific Gas and Electric, Work Paper VMCold, Revision 3, August 2009, Measure Code R97.

349 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. https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/ACEEE_buildings/2002/Panel_10/p10_5/paper.pdf.

350 Pacific Gas and Electric, Work Paper VMReach, Revision 3, August 2009, Measure Code R143.

Table 197. Vending Machine Controls—Non-Refrigerated Snack Unit Deemed Savings[351]

Climate zone	kWh savings	Summer kW savings	Winter kW savings
Zone 1: Amarillo	387	0.005	0.013
Zone 2: Dallas		0.004	0.013
Zone 3: Houston		0.005	0.013
Zone 4: Corpus Christi		0.005	0.014
Zone 5: El Paso		0.003	0.014

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

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).[352]

Program Tracking Data and Evaluation Requirements

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

- Vending machine type - refrigerated cold drink unit, refrigerated reach-in unit, or non-refrigerated snack unit with lighting

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669—Provides energy and demand savings and measure specifications. Appendix A: https://interchange.puc.texas.gov/Documents/40669_3_735684.PDF. Accessed 11/14/2019.
- PUCT Docket 36779—Provides EUL for Vending Machine Controls.

[351] Pacific Gas and Electric, Work Paper VMSnack, Revision 3, August 2009, Measure Code R98.
[352] Database for Energy Efficiency Resources (DEER), http://www.deeresources.com/.

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. https://aceee.org/files/proceedings/2002/data/papers/SS02_Panel10_Paper05.pdf. Accessed 11/14/2019.
- DEER 2014 EUL update.

Document Revision History

Table 198. Nonresidential Vending Machine Controls Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.6.2 Lodging Guest Room Occupancy Sensor Controls Measure Overview

TRM Measure ID: NR-MS-LC

Market Sector: Commercial

Measure Category: HVAC, Indoor Lighting

Applicable Building Types: Hotel/motel guestrooms, schools/colleges (dormitory)

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Energy modeling

Measure Description

This measure, commonly referred to as a guest room energy management (GREM) system, 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 the use of this measure in college dormitories.[353]

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 percent 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.

---

[353] 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 significantly different from the transitory occupation of hotel/motels and even dormitories. This measure is not currently being implemented and is not likely to be used in the future, but it can be added to a future TRM if warranted.

High-Efficiency Condition

The high-efficiency condition is a guest room or dorm room with occupancy controls. The occupancy sensors can control either the HVAC equipment only or the HVAC equipment and the interior lighting (including plug-in lighting).

The occupancy-based control system must include, but not be limited to, infrared sensors, ultrasonic sensors, door magnetic strip sensors, and/or card-key sensors. The controls must be able to either completely shut-off the HVAC equipment serving the space and/or place it into an unoccupied temperature setback/setup mode.

Energy and Demand Savings Methodology

Energy and demand savings are deemed values based on energy simulation runs performed using EnergyPro Version 5. Building prototype models were developed for a hotel, motel, and dormitory building types. 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[354] 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.[355]

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, HVAC + lighting control configurations, and for three facility types: motel guest rooms, hotel guest rooms, and dormitory rooms.

---

354 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.

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

Table 199. Deemed Energy and Demand Savings for Motel per Guest Room, by Region

Climate zone[356]	Heat pump				Electric resistance heat			
	HVAC-Only		HVAC and Lighting		HVAC-only		HVAC and 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 (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 (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 200. Deemed Energy and Demand Savings for Hotel per Guest Room, by Region

Climate zone	Heat pump				Electric heat			
	HVAC-only		HVAC and lighting		HVAC-only		HVAC and 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 (North)	0.073	258	0.093	452	0.073	303	0.093	505
Houston (South)	0.074	242	0.094	430	0.074	260	0.094	450
McAllen (Valley)	0.081	260	0.102	451	0.081	267	0.102	459
El Paso (West)	0.056	178	0.075	360	0.056	196	0.075	380
10-degree setup/setback offset								
Amarillo (Panhandle)	0.102	426	0.121	568	0.102	557	0.121	684
Dallas (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

[356] Regions used in the original petition were mapped to current TRM representative weather stations and regions as follows: Amarillo (Panhandle) was "Panhandle", Dallas-Ft Worth (North) was "North", Houston (South) was "South Central", El Paso (West) was "Big Bend", and McAllen (Valley) was "Rio Grande Valley".

Table 201. Deemed Energy and Demand Savings for Dormitories per Room, by Region

Climate zone	Heat pump				Electric heat			
	HVAC-only		HVAC and lighting		HVAC-only		HVAC and 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 (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 (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, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

Estimated useful life (EUL) is 10 years based on the value for retrofit energy management system (EMS) HVAC control from the Massachusetts Joint Utility Measure Life Study[357]. 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 and 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.

- Climate zone
- HVAC system and equipment type
- Heating type (heat pump, electric resistance)
- Temperature offset category (5 or 10° F)

[357] Energy and 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, HVAC and lighting)
- Building type (hotel, motel, dormitory)
- 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 202. Nonresidential Lodging Guest Room Occupancy Sensor Controls Revision History

TRM version	Date	Description of change
v2.0	04/18/2014	TRM v2.0 origin.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/202	TRM v8.0 update. General reference checks and text edits.

2.6.3 Pump-Off Controllers 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 savings calculation

Savings Methodology: Field study, engineering algorithms, and estimates

Measure Description

Pump-off controllers (POC) are micro-processor-based devices that continuously monitor pump down conditions (i.e., 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"[358] occurs. POCs save energy by optimizing the pump run-times to match the flow conditions of the well.

Eligibility Criteria

The POC measure is only available as a retrofit measure for existing wells (wells with an existing API number[359] 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 or 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 11, 2014) with rod pumps operating on time clock controls or less efficient control devices.

358 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 down stroke causing extreme shock loading of the components which can result in premature equipment failure.

359 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.

High-Efficiency Condition

The efficient condition is the same well, retrofitted with a pump-off controller.

Energy and Demand Savings Methodology

Two main sources were referenced to develop the savings methods for the POC measure: *Electrical Savings in Oil Production*[360] (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,*[361] 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. To develop Texas-specific stipulated values, field and metering data will be collected when there is sufficient uptake in the measure and used to calibrate and update the savings calculation methods and input variables for a future version of the TRM.[362]

Savings Algorithms and Inputs

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

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

Equation 174

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

Equation 175[363]

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

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

Equation 176

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

Equation 177[364]

---

360 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).

361 *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.

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

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

364 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