Under Counter	≤ 0.25~~0.50~~	≤ 1.19	≤ ~~0.50~~0.30	≤ 0.86
Stationary Single Tank Door	≤ ~~0.60~~0.30	≤ 1.18	≤ ~~0.70~~0.55	≤ 0.89
Single Tank Conveyor	≤ ~~1.50~~0.85	≤ 0.79	≤ ~~1.50~~1.20	≤ 0.70
Multiple Tank Conveyor	≤ ~~2.00~~1.00	≤ 0.54	≤ ~~2.25~~1.85	≤ 0.54
Pot, Pan, and Utensil	~~< 1.00~~n/a	~~≤0.58[281]~~n/a	≤ ~~1.20~~0.90	≤ 0.58[282]~~[238]~~

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed savings values are calculated using the following algorithms:

$$\begin{aligned} &Energy\ Savings\ [\Delta kWh] \\ &= (V_{\cancel{waterB}base} - V_{\cancel{waterP}ES}) \times \left(\frac{\Delta T_{DHW} + \Delta T_{boost}}{\eta_{DHW}}\right) \times \rho_{water} \times C_p \times \frac{1\ kWh}{3{,}412\ \cancel{k}Btu\cancel{h}} \\ &+ (\cancel{Idle}E_{idle,base} \\ &- \cancel{Idle}E_{idle,\cancel{post}ES}) \times \left(\cancel{t_{days} \times} t_{hours} - \cancel{t_{days} \times} N_{racks} \times \frac{t_{wash}\cancel{Wash\ Time}}{60}\right) \times t_{days} \end{aligned}$$

Equation 96

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

~~**Equation 96**~~

$$V_{base\cancel{waterB}} = t_{days} \times N_{racks} \times V_{\cancel{gal}rack,base\cancel{B}}$$

Equation 97

$$V_{ES\cancel{waterP}} = t_{days} \times N_{racks} \times V_{\cancel{gal}rack,ES\cancel{P}}$$

Equation 98

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

Equation 99

Where:

ρ_{water} = Density of water [lb/gallon]

C_p = Specific heat of water [Btu/lb °F]

~~[281] Water Consumption for pot, pan and utensil is specified in gallons per square foot rather than gallons per rack.~~

[282] Water Consumption for pot, pan and utensil is specified in gallons per square foot rather than gallons per rack.

ΔT_{DHW} = Inlet water temperature increase for building water heater [ºF]

ΔT_{boost} = Inlet water temperature for booster water heater [ºF]

η_{DHW} = Building electric water heater and booster heater efficiency [%]

N_{racks} = Number of racks washed per days

V_{base} = Baseline annual volume of water consumption [gal/year]

V_{ES} = ENERGY STAR® annual volume of water consumption [gal/year]

$V_{rack,base}$ = Baseline per rack volume of water consumption [gal/rack]

$V_{rack,ES}$ = ENERGY STAR® per rack volume of water consumption [gal/rack]

$E_{Idle,base}$ = Baseline idle energy rate [kW]

$E_{Idle,ES}$ = ENERGY STAR® idle energy rate [kW]

t_{wash} = Wash time per rack [min]

t_{on} = Equipment operating hours per day [hr/day]

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

3,412 = Constant to convert from Btu to kWh

60 = Constant to convert from minutes to hours

CF = Peak coincidence factor

~~V_{waterB} = Baseline volume of water consumed per year [gallons]~~

~~V_{waterP} = Post measure volume of water consumed per year [gallons]~~

~~t_{hours} = Equipment operating hours per day [hours]~~

~~$V_{galrack,B}$ = Gallons of water used per rack of dishes washed for conventional dishwashers [gallons]~~

~~$V_{galrack,P}$ = Gallons of water used per rack of dishes washed for ENERGY STAR® dishwashers [gallons]~~

~~ΔT_{boost} = Inlet water temperature for booster water heater [ºF]~~

~~$Idle_{base}$ = Baseline Idle Energy Rate [kW]~~

~~$Idle_{post}$ = High Efficiency Idle Energy Rate [kW]~~

~~Wash Time = Wash time per Rack~~

Table 137. Dishwashers – ENERGY STAR® Commercial Food Service Calculator Inputs[283]~~Deemed Variables for Energy and Demand Savings Calculations~~

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[283] ENERGY STAR® Commercial Food Service Equipment Calculator. 7/15/21 amendment to March 2021 update. https://www.energystar.gov/products/commercial_food_service_equipment.

Inputs	Under counter	Single door type	Single tank conveyor	Multiple tank conveyor	Pot, pan and utensil
~~t_{days}~~~~[284]~~	~~365~~				
~~t_{hours}~~	~~18~~				
~~CF~~~~[285]~~	~~0.97~~				
ρ_{water}	~~8.208 [lbs/gallon]~~61.4 ÷ 7.48 = 8.2				
C_p	1.0~~ [Btu/lb °F]~~				
ΔT_{DHW}~~[4]~~	Gas Hot Water Heaters: 0ºF Electric Hot Water Heaters: 70 ºF				
ΔT_{boost}	Gas Booster Heaters: 0 ºF Electric Booster Heaters: 40 ºF				
η_{DHW}	98%				
~~ΔT_{boost}~~	~~Gas Booster Heaters: 0 ºF~~ ~~Electric Booster Heaters: 40 ºF~~				
~~η_{boost}~~	~~98%~~				
t_{on}	18				
t_{days}	365				
CF[286]	0.90				
Low-temperature units					
N_{racks}	75	280	400	600	~~N/A~~--
$V_{\cancel{gal}rack,base\cancel{B}}$	1.73	2.10	1.31	1.04	~~N/A~~--
$V_{\cancel{gal}rack,ES\cancel{P}}$	1.19	1.18	0.79	0.54	~~N/A~~--
~~Idle~~$E_{idle,base}$	0.50	0.60	1.60	2.00	~~N/A~~--
~~Idle~~$E_{idle,\cancel{post}ES}$	~~0.50~~0.25	~~0.60~~0.30	~~1.50~~0.85	~~2.00~~1.00	~~N/A~~--
t_{wash}~~Wash Time~~	2.0	1.5	0.3	0.3	~~N/A~~--

~~[284] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 12/16/2013.~~

~~[285] California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12/12.~~

[286] Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

Inputs	Under counter	Single door type	Single tank conveyor	Multiple tank conveyor	Pot, pan and utensil
High-temperature units					
N_{racks}	75	280	400	600	280
V~~gal~~rack,base~~B~~	1.09	1.29	0.87	0.97	0.70
V~~gal~~rack,ES~~P~~	0.86	0.89	0.70	0.54	0.58
~~Idle~~Eidle,base	0.76	0.87	1.93	2.59	1.20
~~Idle~~Eidle,~~post~~ES	~~0.50~~0.30	~~0.70~~0.55	~~1.50~~1.20	~~2.25~~1.85	~~1.20~~0.90
t_{wash}~~Wash Time~~	2.0	1.0	0.3	0.2	3.0

Deemed Energy and Demand Savings Tables

The following deemed energy and demand savings are based on the input assumptions from Table 137~~Table 137~~.~~ 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 138. Dishwashers – Deemed Energy and ~~Peak~~ Demand Savings Values~~ by Dishwasher~~

Facility description	Under counter		Stationary single tank door~~Door type~~		Single tank conveyor		Multiple-tank conveyor		Pot, pan, and utensil	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Low Temp./ Electric Hot Water Heater	3,955~~2,540~~	0.542~~0.375~~	17,362~~16,153~~	2.378~~2.385~~	17,426~~13,626~~	2.387~~2.012~~	24,292~~18,811~~	3.328~~2.777~~	--~~NA~~	--~~NA~~
High Temp./ Electric Hot Water Heater with Electric Booster Heater	4,303~~3,171~~	0.589~~0.468~~	12,596~~11,863~~	1.726~~1.751~~	10,966~~9,212~~	1.502~~1.360~~	29,751~~27,408~~	4.075~~4.046~~	3,750~~3,311~~	0.514~~0.489~~
High Temp./ Gas Hot Water Heater with Electric Booster Heater	3,221~~2,089~~	0.441~~0.308~~	5,572~~4,840~~	0.763~~0.715~~	6,700~~4,948~~	0.918~~0.730~~	13,569~~11,230~~	1.859~~1.658~~	1,642~~1,204~~	0.225~~0.178~~
High Temp./ Electric Hot Water Heater with Gas Booster Heater	3,684	0.505	8,582	1.176	8,528	1.168	20,504	2.809	2,545	0.349

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) varies per eligible dishwasher type, as stated in the ENERGY STAR® ~~v2.0~~ Commercial Kitchen Equipment Savings Calculator~~[287]~~. ~~The Equipment Lifetime is tabulated per Dishwasher type in Table 139.~~

Table 139. Dishwashers – Equipment Lifetime by Machine Type~~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

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 m~~Manufacturer and model number
- Energy source for primary water heater (gas, electric)
- Energy source for booster water heater (gas, electric)
- ENERGY STAR® idle rate
- ENERGY STAR® water consumption
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

~~[287] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 07/2020.~~

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 140. 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.
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.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Incorporated March 2021 calculator update. Updated variable definitions.

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 h~~H~~ot ~~F~~food ~~H~~holding ~~C~~cabinet (HFHC) 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~~ HFHCs that ~~meet~~ have earned ENERGY STAR® ~~specifications~~ certification 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~~HFHCs must be compliant with the current ENERGY STAR® ~~certified~~specification.[288,289]~~[290]~~ Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[291]

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[288] ENERGY STAR® Program Requirements Product Specifications for Commercial Hot Food Holding Cabinets. Eligibility Criteria Version 2.0. https://www.energystar.gov/sites/default/files/specs/private/Commercial_HFHC_Program_Requirements_2.0.pdf.

[289] ENERGY STAR® Qualified Product Listing: https://www.energystar.gov/productfinder/product/certified-commercial-hot-food-holding-cabinets/results.

~~[290] 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.~~

[291] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://library.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Mar2021.pdf.~~http~~

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

- Dual function equipment (e.g., “cook-and-hold” and proofing units)
- 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 141~~Table 141~~ summarizes idle energy rate requirement based on cabinet interior volume.

Table 141. HFHCs – ENERGY STAR® Specification[292]~~,Maximum Idle Energy Rate Requirements ENERGY STAR® Qualification~~[293]

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:

$$Energy\ Saving\ [\Delta kWh] = \left(E_{Idle,base\cancel{B}} - E_{Idle,ES\cancel{P}}\right) \times \frac{1}{1000} \times t_{\cancel{hrs}on} \times t_{days}$$

Equation 100

~~://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.~~

[292] ENERGY STAR® Commercial Fryers Key Product Criteria. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_hot_food_holding_cabinets/key_product_criteria.

[293] 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.~~

$$Peak\ Demand\ [\Delta kW] = \left(E_{Idle,base\cancel{B}} - E_{Idle,ES\cancel{P}}\right) \times \frac{1}{1000} \times CF$$

Equation 101

Where:

V = Product interior volume [ft^3]

$E_{Idle,base\cancel{B}}$ = Baseline idle energy rate [W]~~(See Table 134)~~

$E_{Idle,ES\cancel{P}}$ = ENERGY STAR® ~~I~~idle energy rate after installation [W]~~(See Table 134)~~

~~*V = Product Interior Volume [ft^3]*~~

$t_{\cancel{hrs}on}$ = Equipment operating hours per day [hrs/day]

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

CF = Peak coincidence factor

Table 142. HFHCs – ENERGY STAR® Commercial Food Service Calculator Inputs[294]~~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)~~V[295]	8	22	53
~~Baseline Equipment Idle Energy Rate (~~$E_{Idle,base\cancel{B}}$~~)[296]~~	~~40~~ 30 × V		
~~Assumed Baseline Equipment Idle Energy Rate (E_{IdleB})~~	~~320~~	~~880~~	~~2,120~~
~~Efficient Equipment Idle Energy Rate (~~$E_{Idle,ES\cancel{P}}$~~)~~	21.5 × V	2 × V + 254	3.8 × V +203.5
~~Operating Hours per Day (~~$t_{\cancel{hours}on}$~~)~~	~~15~~9		
~~Facility Operating Days per Year (~~t_{days}~~)~~	365		
~~Peak Coincidence Factor[297] (~~CF[298]~~)~~	~~0.92~~0.90		

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[294] ENERGY STAR® Commercial Food Service Equipment Calculator. 7/15/21 amendment to March 2021 update. https://www.energystar.gov/products/commercial_food_service_equipment.

[295] Averages of product interior volume determined based on review of ENERGY STAR® qualified product listing. Accessed 7/30/2020.

~~[296] 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.~~

~~[297] California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12/12.~~

[298] Itron, Inc., “2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report.” Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

Deemed Energy and Demand Savings Tables

The following deemed energy and demand savings are based on the input assumptions from Table 142 ~~Table 142 of electric hot food holding cabinets are deemed values. The following tables provide these deemed values.~~

Table 143. HFHCs – 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	223~~1,215~~	0.061~~0.204~~
13 ≤ V < 28	1,189~~2,770~~	0.326~~0.466~~
28 ≤ V	3,893~~4,832~~	1.067~~0.812~~

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) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-HoldCab.[299]

~~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[300] 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.

- Manufacturer and model number
- ~~Baseline equipment interior cabinet volume~~
- ~~Baseline equipment idle energy rate~~
- ~~Post-retrofit equipment i~~Interior cabinet volume
- ENERGY STAR® idle rate

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[299] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

~~[300] 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.~~

- Copy of ENERGY STAR® certification or alternative
- 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.

Document Revision History

Table 144. 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.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update. Updated EUL reference.

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 Fryers. Fryers that have earned ~~the~~ ENERGY STAR® ~~rating~~ certification 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 be compliant with the current ENERGY STAR® ~~qualifications~~specification, either counter-top or floor type designs, with standard-size and large vat fryers as defined ~~by ENERGY STAR. ®~~below.[301][302]

- 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

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[301] ENERGY STAR® Program Requirements Product Specifications for ~~Electric~~ Commercial Fryers. Eligibility Criteria Version 3~~2~~.0. https://www.energystar.gov/sites/default/files/Commercial%20Fryers%20Program%20Requirements.pdf. ~~https://www.energystar.gov/sites/default/files/specs/private/Commercial_Fryers_Program_Requirements.pdf. Accessed 11/13/19.~~

[302] ENERGY STAR® Qualified Product Listing: https://www.energystar.gov/productfinder/product/certified-commercial-fryers/results.

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[303]

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® v3.0 specification, effective October 1, 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 145~~Table 145~~.

Table 145. Fryers – ENERGY STAR® Specification[304]~~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:

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

Equation 102

$$kWh_{base} = kWh_{ph,base} + kWh_{cook,base} + kWh_{idle,base}$$

Equation 103

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[303] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://library.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Mar2021.pdf.~~http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf~~. ~~Accessed 04/30/2015.~~

[304] ENERGY STAR® Commercial Fryers Key Product Criteria. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_fryers/key_product_criteria.

$$kWh_{ES} = kWh_{ph,ES} + kWh_{cook,ES} + kWh_{idle,ES}$$

Equation 104

kWh_{ph}, kWh_{cook}, and kWh_{idle} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in Equation 105~~Equation 105~~, except they require their respective input assumptions relative to preheat, cooking, and idle operation as seen in Table 146~~Table 146~~.

$$kWh = \left(E_{ph} + \left(\frac{W_{food} \times E_{food}}{\eta_{cook}}\right) + E_{idle} \times \left(t_{on} - \frac{t_{ph}}{60} - \frac{W_{food}}{PC}\right)\right) \times \frac{t_{days}}{1000}$$

Equation 105

$$Peak\ Demand\ [\Delta kW] = \frac{\Delta kWh - \left(\frac{\Delta E_{ph} \times t_{days}}{1000}\right)}{t_{on} \times t_{days}} \times CF$$

Equation 106

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

~~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~~$_{post}$~~$_{ES}$ = *~~Post~~ ENERGY STAR® annual energy consumption [kWh]*

E_{ph} = *Preheat energy [Wh/BTU]*

ΔE_{ph} = *Difference in baseline and ENERGY STAR® preheat energy*

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

E_{food} = ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]

η_{cook}~~ingP~~ = ~~Post measure c~~Cooking energy efficiency [%]

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

E_{Idle}~~P~~ = ~~Post measure i~~Idle energy rate [W]

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

PC~~CapP~~ = ~~Post measure p~~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~~$_{on}$ = ~~Average daily~~Equipment operating hours per day [hr/day]

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

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

1000 = Wh to kWh conversion

CF = Peak coincidence factor

Table 146. Fryers – ENERGY STAR® Commercial Food Service Calculator Inputs[305]~~Deemed Variables for Energy and Demand Savings Calculations[306]~~

Parameter	Standard-sized vat		Large vat	
	Baseline	~~Post retrofit~~ENERGY STAR®	Baseline	ENERGY STAR®~~Post retrofit~~
~~kWh_{base}~~	~~See Table 139~~			
~~kWh_{post}~~				
E_{ph}	2,400	1,900	2,400	1,900
W_{food}	150			
~~t_{OpHrs}~~	~~16~~		~~12~~	
~~t_{days}~~	~~365~~			
~~CF[307]~~	~~0.92~~			
E_{food}	167			
$\eta_{cooking}$	75%	83%	70%	80%
E_{idle}	~~1,050~~1,200	800	1,350	~~1,110~~1,100
$PC_{~~Cap~~}$	65	70	100	110
t_{on}	16		12	
t_{days}	365			
CF[308]	0.90			

Deemed Energy and Demand Savings Tables

The following deemed energy and demand savings of ~~Electric Fryers are deemed values. Table 139 provides these deemed values.~~are based on the assumptions from Table 146~~Table 146~~.

Table 147. Fryers - Deemed Energy and Demand Savings Values ~~by Fryer Type~~

Fryer ~~T~~type	Annual ~~E~~energy ~~S~~savings (kWh)	Peak ~~D~~demand ~~S~~savings (kW)
Standard	3,272~~2,376~~	0.476~~0.374~~

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[305] ENERGY STAR® Commercial Food Service Equipment Calculator. 7/15/21 amendment to March 2021 update. https://www.energystar.gov/products/commercial_food_service_equipment.

[306] ~~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.~~

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

[308] Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

Large ~~V~~vat	2,696~~2,497~~	0.516~~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 estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-ElecFryer.[309]

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

Program Tracking Data 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
- Fryer width
- ENERGY STAR® idle rate
- ENERGY STAR® ~~High-efficiency unit heavy load~~ cooking efficiency
- ~~High-efficiency unit equipment idle rate~~
- ~~Fryer width~~
- Copy of ENERGY STAR® certification or alternative
- 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.

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[309] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

Document Revision History

Table 148. 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.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update. Updated EUL reference.

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 ~~S~~steam ~~C~~cookers. Steam cookers are available in 3, 4, 5, or ≥ 6 pan capacities. Steam cookers that have earned ENERGY STAR® ~~qualified~~ certification ~~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 e~~Eligible units must be compliant with the current ~~equipment is found on the~~ ENERGY STAR® ~~list of qualified equipment~~specification.[310],[311] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[312]~~.~~

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

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[310] ENERGY STAR® Program Requirements Product Specifications for Commercial Steam Cookers. Eligibility Criteria Version 1.2. https://www.energystar.gov/sites/default/files/specs/private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf.

[311] ENERGY STAR® Product Listing: https://www.energystar.gov/productfinder/product/certified-commercial-steam-cookers/results.~~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.~~

[312] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://library.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Mar2021.pdf.~~http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.~~

Baseline Condition

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

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v1.2 specification, effective August 1, 2003. Qualified products must meet the requirements from Table 149.

Table 149. Steam Cookers – ENERGY STAR® ~~Energy Efficiency and Idle Rate Requirements for Electric Steam Cookers~~Specification[313]

Pan Capacity	Cooking Energy Efficiency (%)[314]	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

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

Equation 107

$$kWh_{base} = kWh_{ph,base} + kWh_{cook,base} + kWh_{idle,base}$$

Equation 108

$$kWh_{ES} = kWh_{ph,ES} + kWh_{cook,ES} + kWh_{idle,ES}$$

Equation 109

kWh_{ph}, kWh_{cook}, and kWh_{idle} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in Equation 94~~Equation 94~~, except they require their respective input assumptions relative to preheat, cooking, and idle operation as seen in Table 150~~Table 150~~.

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

[314] 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.

$$kWh = \left(E_{ph} + \left(\frac{W_{food} \times E_{food}}{\eta_{\text{cook}}}\right) + \left[(1 - 40\%) \times E_{idle} + \frac{40\% \times PC \times P}{\eta_{\text{cook}}}\right] \times \left(t_{on} - \frac{W_{food}}{PC \times P}\right)\right) \times \frac{t_{days}}{1000}$$

Equation 110

$$Peak\ Demand\ [\Delta kW] = \frac{\Delta kWh - \left(\frac{\Delta E_{ph} \times t_{days}}{1000}\right)}{t_{on} \times t_{days}} \times CF$$

Equation 111

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

~~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~~

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

~~Equation 108~~

Where:

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

kWh~~$_{post}$~~$_{ES}$ = ~~Post~~ ENERGY STAR® annual energy consumption [kWh]

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

E_{ph} = Preheat energy [Wh/BTU]

ΔE_{ph} = Difference in baseline and ENERGY STAR® preheat energy

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

E_{food} = ASTM energy to food of energy absorbed by food product during

cooking [Wh/lb]

η~~$_{base}$~~$_{cook}$ = ~~Baseline~~ Cooking energy efficiency [%] (Differs for boiler-based or steam generator equipment)

~~η_{post} = Post-retrofit Cooking energy efficiency~~

~~η_{tSteam}~~40% = Percent of time in constant steam mode [%]

E_{Idle}~~$_{Rate, base}$~~ = Idle energy rate [W]. (Differs for boiler-based ~~or~~ and steam-generator equipment)

~~$E_{IdleRate, post}$ = Idle energy rate [W].~~

PC~~$_{pan}$~~ = Production capacity ~~per pan~~ [lb/hr]

P~~N_{pan}~~ = ~~Number of pans~~Pan capacity

~~N_{OpDays} = Facility operating days per year [days/yr]~~

t~~$_{OpHrs}$~~$_{on}$ = ~~Average daily~~ Equipment operating hours per day [hr/day]

~~CF = Peak coincidence factor~~

1000 = Wh to kWh conversion factor

CF = Peak coincidence factor

Table 150. Steam Cookers – ENERGY STAR® Commercial Food Service Calculator Inputs[315]~~Deemed Variables for Energy and Demand Savings Calculations~~~~[316]~~

Parameter	Baseline value	~~Post-retrofit~~ ENERGYSTAR® value
~~kWh_{base}~~		~~See Table 143~~
~~kWh_{post}~~		
E_{ph}	1,776	1,671.7
W_{food}		100
E_{food}		30.8
η	Boiler-based ~~Efficiency~~: 26% Steam-Generator ~~Efficiency~~: 30%	50%
~~η_{tSteam}~~		~~40%~~
E_{Idle}~~$_{Rate}$~~	Boiler-based ~~Idle Rate~~: 1,000 Steam Generator ~~Idle Rate~~: 1,200	3-Pan: 400 4-Pan: 530 5-Pan: 670 6-Pan: 800
PC~~$_{pan}$~~	23.3	16.7
P~~N_{pan}~~		3, 4, 5, or 6
t~~$_{OpHrs}$~~$_{on}$		~~12~~9.25
t~~N_{OpD}~~$_{days}$		~~365~~311
CF[317]~~[318]~~		~~0.92~~0.90

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[315] ENERGY STAR® Commercial Food Service Equipment Calculator. 7/15/21 amendment to March 2021 update. https://www.energystar.gov/products/commercial_food_service_equipment.

~~[316] 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.~~

[317] Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

~~[318] 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 following deemed 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.~~are based on the input assumptions from Table 150~~Table 150~~.

Table 151. Steam Cookers – Deemed Energy and Demand Savings Values~~Annual Energy Consumption and Daily Food Cooked~~~~[319]~~

Steam cooker type	~~N_{pan}~~P	Annual energy savings (kWh)	Peak demand savings (kW)
Boiler ~~B~~based	3-Pan	7,988~~11,784~~	2.489~~2.475~~
	4-Pan	9,822~~14,553~~	3.063~~3.057~~
	5-Pan	11,614~~17,268~~	3.623~~3.627~~
	6-Pan and ~~L~~larger	13,408~~19,990~~	4.185~~4.199~~
Steam ~~G~~generator	3-Pan	6,715~~9,967~~	2.091~~2.093~~
	4-Pan	8,139~~12,107~~	2.536~~2.543~~
	5-Pan	9,515~~14,186~~	2.967~~2.980~~
	6-Pan and ~~L~~larger	10,891~~16,270~~	3.397~~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 estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-ElecStmCooker.[320]

~~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).~~

~~[319] 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.~~

[320] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

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 m~~Manufacturer and model number
- Steam cooker type (boiler-based or steam generator)
- ~~Number of pans~~Pan capacity (3, 4, 5, or 6+)
- ENERGY STAR® idle rate
- ENERGY STAR® cooking efficiency
- Copy of ENERGY STAR® certification or alternative
- 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 152. 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.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update. Corrected formula errors. Updated EUL reference.

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. Eligible units must be compliant with the current ENERGY STAR® specification.[321,322]

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.[323]

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

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[321] ENERGY STAR® Program Requirements Product Specifications for Commercial Ice Makes. Eligibility Criteria Version 3.0. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Draft%20Version%203.0%20Automatic%20Commercial%20Ice%20Maker%20Specification.pdf.

[322] ENERGY STAR® Qualified Product Listing: https://www.energystar.gov/productfinder/product/certified-commercial-ice-machines/results.

[323] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://library.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Mar2021.pdf. ~~https://library.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_January2015.pdf. Accessed 07/2020.~~

Baseline Condition

The baseline condition is an ice maker meeting the federal standards published in 10 CFR 431 listed in Table 153. 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.

Table 153. Ice Makers – Federal Standard ~~Baseline Efficiency~~[324]

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

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[324] Code of Federal Regulations, Title 10 Part 431.136 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://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=53 ~~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 154.

Table 154. Ice Makers – ENERGY STAR® ~~Criteria—Automatic Ice Makers~~Specification[325]

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~~[326]~~ for the purpose of possibly ~~deeming energy and demand savings~~establishing deemed savings~~,~~ but were determined to be too variable~~ to be utilized as assumptions in computed deemed savings.~~

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[325] 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.~~

~~[326] 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.~~

~~A strictly algorithmic approach was thus opted for~~. Therefore, ~~S~~savings for air-cooled batch and continuous ~~C~~commercial ~~I~~ice ~~M~~makers are dependent on the Harvest Rate and can be calculated using the following algorithms.

Savings Algorithms and Input Variables

$$\cancel{Annual}\ Energy\ Savings\ [\Delta kWh] = (\cancel{UseRate}E_{base} - \cancel{UseRate}E_{\mathrm{ES}\cancel{\mathrm{TAR}}}) \times \frac{H\cancel{arvest\ Rate}}{100} \times DC\cancel{uty\ Cycle} \times t_{days}\cancel{Days}$$

Equation 112

$$Peak\ Demand\ \cancel{Savings}\ [\Delta kW] = \Delta kWh\cancel{Annual\ Energy\ Savings} \times PLS$$

Equation 113

Where:

$\cancel{UseRate}E_{base}$ = *~~The~~ Baseline rated energy consumption (kWh) per 100 pounds of ice, Table 153~~Table 153 of the baseline machine.~~*

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$\cancel{UseRate}E_{ES\cancel{TAR}}$ = *~~The~~ ENERGY STAR® rated energy consumption (kWh) per 100 pounds of ice, see Table 154~~Table 154~~*

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H~~arvest Rate~~ = *Harvest rate in ~~P~~pounds of ice produced per 24 hours*

DC~~uty Cycle~~ = *Machine duty cycle, ~~80~~75%*[327]

t_{days}~~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, see Table 155~~Table 155~~*

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Table 155. Ice Makers – Probability-Weighted Peak Load Share~~—Ice Makers~~

Probability weighted peak load share (PLS)[328]		
Climate zone	**Summer peak**	**Winter peak**
1	0.00012	0.00011
2		
3		
4		0.00012
5		

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[327] 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.

[328] 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.[329]

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:

- Manufacturer and model number
- Machine type
    - IMH, RC, or SCU
    - Batch or continuous
- Machine harvest rate
- Climate zone
- ~~Annual days of use~~
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

~~None~~Not applicable.

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[329] 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.

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~~.

Document Revision History

Table 156. 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.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update.

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.[330] 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).[331] This output is adjusted by population to account for the percentage of sites with electric resistance or heat pump heating.[332] Additionally, because output from the OALC is per 1,000 CFM, a CFM per HP ratio[333] 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 114

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

Equation 115

Where:

$AvgSav_{kWh/_{HP}}$ = *Average hourly energy savings per horsepower based on the building type, see Table 157~~Table 157~~*

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

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

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

[332] 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.~~

[333] 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 157~~Table 157~~*

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$Days_{yr}$ = *Number of operational days per year, facility specific; if unknown use defaults from Table 157~~Table 157~~*

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MAU = *Make-up Air Unit factor applied to account for presence of dedicated MAU; value = 1 if there is a dedicated MAU; see Table 157~~Table 157~~ for values when there is no dedicated MAU*

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$Savings_{interactive/HP}$ = *Interactive heating savings per 1,000 CFM of outdoor air; see Table 158~~Table 158~~*

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$PWPLS$ = *Probability Weighted Peak Load Share; see Table 159~~Table 159~~*

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Table 157. Demand Controlled Kitchen Ventilation—~~-~~Default Assumptions

Building type	$AvgSav_{kWh/HP}$	Hrs_{day}	$Days_{yr}$	MAU factor with no dedicated MAU
Casual Dining/Fast Food[334]	0.650	15	365	0.65
24-Hr Restaurant/Hotel[335]	0.631	24	365	0.65
School Café with summer[336]	0.566	11	325	0.51
School Café without summer	0.566	11	252	0.51

Table 158. 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

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

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

[336] 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 157~~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 159. Demand Controlled Kitchen Ventilation—Probability Weighted Peak Load Share[337]

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 160. 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

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[337] PWPLS factors are calculated according to the methods described in TRM Volume 1, Section 4.3. The load shape source is the Pacific North~~t~~west 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 161. 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) is 15 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID HVAC-VSD-fan.[338]

~~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.

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[338] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 162. 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.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

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 164~~Table 164~~

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 163 (on a per product class or ozf, i.e., spray force in ounce-force, basis).

Baseline Condition

Effective January 28, 2019, ~~eligible~~ reference 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 163.[339]

Table 163. 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

---

[339] Federal Energy Conservation Standard, Code of Federal Regulations, Title 10, Chapter 22, Subchapter D, Part 431, Subpart O, Section §431.266.~~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~~pre-rinse ~~S~~spray ~~V~~valves.[340]~~.~~ 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 valve ~~which~~ that has a flow rate no greater than the flow rate specified in Table 163 for the pre-rinse spray valve's respective product class. The sprayer should be capable of the same cleaning ability as the old sprayer.[341]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy and demand savings are calculated using the following algorithms:

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

Equation 116

$$Peak\ Demand\ [\Delta kW] = \frac{Energy\ Savings\ [\Delta kWh] \times PLS}{100{,}000}$$

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

Equation 117

Where:

F_B = ~~*Average b*~~*Baseline flow rate of sprayer (GPM), see Table 163*~~*Table 163*~~

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~~F_P =~~ ~~*Average p*~~*Post measure flow rate of sprayer (GPM), use actual value*

$U_{\cancel{B}}$ = ~~*Baseline w*~~*Water usage duration, see Table 164*~~*Table 164*~~

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~~U_P = *Post-retrofit water usage duration*~~

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[340] "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.

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

T_H = *Average mixed hot water (after spray valve) temperature (°F), 140.5°F*[342]

T_C = *Average supply (cold) water temperature (°F), 71.4°F*[343]

Days = *Annual facility operating days for the applications, see Table 164~~Table 164~~*

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C_H = *Unit conversion for water density: 8.33 ~~BTU/(Gallons-°F)~~lbs/gallon*

C_E = *Unit conversion: 1 BTU = 0.00029308 kWh (1/3412)*

Eff_E = *Recovery efficiency ~~Efficiency~~ of electric water heater, 0.98*[344]

P = *Hourly peak demand as percent of daily demand Probability-weighted peak load share, see Table 165~~Table 165~~*

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Table 164. Assumed Variables for Energy and Demand Savings Calculations

Variable	Assumed value
~~F_B~~	~~See Table 155~~
U~~$_B$ =U_P~~[345]	Fast Food Restaurant: 45 min/day/unit~~[346]~~ 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~~[347]~~
~~T_H~~	~~120[348]~~

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[342] Texas Administrative Code for Retail Food Equipment Operations, Title 25, Part 1, Chapter 228, Subchapter D, Rule §228.111. Average of minimum values for manual warewashing equipment, 110°F (paragraph (i)) and 171°F (paragraph (k)). https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=25&pt=1&ch=228&rl=111.

[343] Average calculated input water temperature for five Texas climate zone cities, based on typical meteorological year (TMY) dataset for TMY3: Available at http://texasefficiency.com/index.php/regulatory-filings/deemed-savings.

[344] Recovery efficiency of electric water heaters as listed on the AHRI Directory of Certified Product Performance. https://www.ahridirectory.org.

[345] "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.

~~[346] "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.~~

~~[347] 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.~~

~~[348] 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.~~

Variable	Assumed value
~~T_C~~	~~69[349]~~
Days[350]	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[351]~~	~~Fast Food Restaurant: 6.81%~~ ~~Casual Dining Restaurant: 17.36%~~ ~~Institutional: 5.85%~~ ~~Dormitory: 17.36%~~ ~~K-12 School: 11.35%~~

~~[349] 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.~~

[350] 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.

~~[351] 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.~~

Table 165. Probability-weighted Peak Load Share[352]

Climate Zone	Summer PLS			Winter PLS		
	Full-service restaurant and cafeterias	Fast-food	Schools	Full-service restaurant and cafeterias	Fast-food	Schools
Zone 1: Amarillo	3.151	6.298	2.537	5.026	6.205	0.666
Zone 2: Dallas	4.767	5.850	2.630	4.279	5.868	0.899
Zone 3: Houston	3.544	6.237	2.627	3.219	5.015	1.556
Zone 4: Corpus Christi	3.092	6.214	2.768	5.462	6.754	1.561
Zone 5: El Paso	6.805	5.660	3.934	7.063	8.490	0.000

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 estimated useful life (EUL) is 5 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-LowPreRinse.[353]

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

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

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[352] Peak load share factors are developed according to the method described in the Texas TRM Volume 1, using load profiles derived from the American Society of Heating Refrigeration and Air-Conditioning Engineers, Inc., ASHRAE Handbook 20112019. HVAC Applications. Chapter 50 51 - Service Water Heating, Section 9 – Hot Water Load and Equipment Sizing, Figure 24 – Hourly Flow Profiles for Various Building Types. PLS values are multiplied by 100,000 to allow for easier readability of the values.

[353] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

- 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 166. 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.
V9.0		TRM v9.0 update. General reference checks, updates to input assumptions, and update peak demand savings. Updated EUL reference.

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.[354] 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.[355] 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 167. 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.[356]

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[354] "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.

[355] See Volume 1, Section 4.

[356] "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 168. Nonresidential Vacuum-Sealing & Packaging Machines Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.
v9.0	10/2021	TRM v9.0 update. No revisions.

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- horizontal 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~~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 118[357]

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 42.89ºF DP and all on (duty cycle of 100%) at 52.87ºF DP for a typical supermarket.[358] Between these values, the door heaters' duty cycle changes proportionally:

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

Equation 119

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[359] at:

For medium temperature (coolers):

$$kW_{ASH} = 0.109\ per\ door\ or\ 0.0436\ per\ horizontal\ linear\ foot\ of\ door$$[360]

Equation 120

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[357] San Diego Gas & Electric, Work Paper WPSDGENRRN0009: Anti-Sweat Heat (ASH) Controls, "Energy Savings Estimation Methodologies". page 4, Figure 2. August 2012. https://www.sdge.com/sites/default/files/WPSDGENRRN0009%2520Rev%25200%2520Anti-Sweat%2520Heat%2520%2528ASH%2529%2520Controls%2520_0.doc.

[358] Ibid, "Direct ASH Power", page 6.

42.89ºF DP and 52.87ºF DP correspond to relative humidities of 35% and 50% respectively for a 72ºF indoor space. These relative humidity values are common practice setpoints for a typical supermarket of this temperature.

[359] 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.

[360] Ibid.

For low temperature (freezers):

$$kW_{ASH} = 0.191\ per\ door\ or\ 0.0764\ per\ \underline{horizontal}\ linear\ foot\ of\ door^{361}$$

Equation 121

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 122

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

Equation 123

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,[362] the cooling load contribution from door heaters for each hour of the year 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 124

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 ($SCT_{\underline{MT}}$) is calculated as the design dry-bulb temperature plus 15 degrees. For low-temperature refrigerated cases, the $SCT_{\underline{LT}}$ 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.[363]

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[361] Ibid.

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

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

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

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

Equation 125[364]

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*

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] for each hour of the year:

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

Equation 126[365]

Where:

a = *9.86650982829017*

b = *-0.230356886617629*

c = *22.905553824974*

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[364] San Diego Gas & Electric, Work Paper WPSDGENRRN0009: Anti-Sweat Heat (ASH) Controls, “Energy Savings Estimation Methodologies”. page 4, Figure 2. August 2012. https://www.sdge.com/sites/default/files/WPSDGENRRN0009%2520Rev%25200%2520Anti-Sweat%2520Heat%2520%2528ASH%2529%2520Controls%2520_0.doc.

[365] Ibid.

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*

$SCT_{\underline{LT}}$ = $T_{db} + 10$

T_{DB} = *Dry Bulb Temperature*

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 127

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

Equation 128

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

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

Equation 129

Total energy savings is ~~a result of~~ the difference between the baseline and post~~-R~~retrofit case:

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

Equation 130

Peak demand savings are calculated as the weighted average of the probability of winter or summer peak load's top twenty hours' coincidence with system peak and the hourly calculated kWh_{total} for said twenty hours per climate zone.~~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, with hourly dry bulb temperatures and outdoor dew points determined using TMY3 Hourly Weather Data by Climate Zone.[366]~~.~~ The following table provides these deemed values.

Table 169. Annual Deemed Energy and Demand Savings Values per Horizontal Linear Foot of Door 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	342~~364~~	0.047~~0.007~~	610~~668~~	0.081~~0.015~~
Zone 2: Dallas	232~~249~~	0.047~~0.005~~	413~~457~~	0.081~~0.011~~
Zone 3: Houston	170~~180~~	0.047~~0.003~~	304~~330~~	0.082~~0.007~~
Zone 4: ~~McAllen~~Corpus Christi	131~~137~~	0.047~~0.003~~	234~~251~~	0.083~~0.006~~
Zone 5: El Paso	380~~405~~	0.047~~0.008~~	682~~745~~	0.084~~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 estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocDisp-ASH.[367]

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[366] http://texasefficiency.com/index.php/regulatory-filings/deemed-savings

[367] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

~~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).~~[368]

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 (medium, low)
- Linear feet of door length

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

Relevant Standards and Reference Sources

- DEER 2014 EUL update
- TMY3 Hourly Weather Data by Climate Zone[369]

Document Revision History

Table 170. 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.

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[368] ~~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.~~

[369] http://texasefficiency.com/index.php/regulatory-filings/deemed-savings

TRM version	Date	Description of change
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 125~~Equation 125~~ and Equation 126~~Equation 126~~.
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.
v9.0	10/2021	TRM v9.0 update. Updated peak demand methodology to follow Volume 1 methods. Changed Zone 4 reference location from McAllen to Corpus Christi. Updated EUL reference.

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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~~ algorithm 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 131

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

Equation 132

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

Equation 133

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

Equation 134

Freezer

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

Equation 135

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

Equation 136

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

Equation 137

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

Equation 138

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} = $12/EER_{MT}$*, the coefficient of performance of compressor in the cooler* ~~*Coefficient of performance of compressor in the cooler*~~

$COP_{freezer}$ = $12/EER_{LT}$*, the coefficient of performance of compressor in the 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*[370] *for walk-ins (see Table 171*~~*Table 171*~~*)*

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%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%.*[371]

The compressor power requirements are based on calculated cooling load and energy-efficiency ratios obtained from manufacturers' data, as described below.

For medium temperature refrigerated cases, the saturated condensing temperature (SCT_{MT}) is calculated as the design dry-bulb temperature plus 15 degrees. For low-temperature refrigerated cases, the SCT_{LT} 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.[372]

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[370] 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.**~~Table 163~~~~**Error! Reference source not found.**~~ for the $DC_{EvapFreezer}$ variable. The 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.

[371] 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."

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

For medium temperature compressors, the following equation is used to determine EER_{MT} [Btu/hr/watts] for each hour of the year.

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

Equation 139[373]

Where:

a = *3.75346018700468*

b = *-0.049642253137389*

c = *29.4589834935596*

d = *0.000342066982768282*

e = *-11.7705583766926*

f = *-0.212941092717051*

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

h = *6.80170133906075*

I = *-0.020187240339536*

j = *0.000657941213335828*

PLR = *1/1.15 = 0.87*

SCT_{MT} = $T_{db} + 15$

T_{DB} = *Dry Bulb Temperature*

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

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

Equation 140[374]

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[373] San Diego Gas & Electric, Work Paper WPSDGENRRN0009: Anti-Sweat Heat (ASH) Controls, “Energy Savings Estimation Methodologies”. page 4, Figure 2. August 2012. https://www.sdge.com/sites/default/files/WPSDGENRRN0009%2520Rev%25200%2520Anti-Sweat%2520Heat%2520%2528ASH%2529%2520Controls%2520_0.doc.

[374] Ibid.

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_{LT} = T_{db} +10

T_{DB} = Dry Bulb Temperature

Table 171. Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed values
W_{base}	See Table 172~~Table 172~~
W_{ee}	See Table 172~~Table 172~~
LF[375]	0.9
$DC_{EvapCool}$[376]	100%
$DC_{EvapFreeze}$[377]	94.4%
COP_{cooler}	12/EER_{MT}~~See Table 165~~
$COP_{freezer}$	12/EER_{LT}~~See Table 165~~

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[375] 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.

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

[377] See footnotes 370~~293~~ and 376~~296~~.

Hours[378]	8,760 or 8,273
%OFF	0 or 46%

Table 172. Motor Sizes, Efficiencies, and Input Watts[379,380]

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	30%~~18%~~	30~~50~~	60%~~41%~~	15~~22~~	70%~~66%~~	13~~14~~
1/40 HP (16-23W)	19.5	30%~~21%~~	65~~93~~	60%~~41%~~	33~~48~~	70%~~66%~~	28~~30~~
1/20 HP (37W)	37	30%~~26%~~	123~~142~~	60%~~41%~~	62~~90~~	70%~~66%~~	53~~56~~
1/15 HP (49W)	49.0	30%~~26%~~	163~~188~~	60%~~41%~~	82~~120~~	70%~~66%~~	70~~74~~
1/4 HP	186.5	30%~~33%~~	622~~559~~	60%~~41%~~	311~~455~~	70%~~66%~~	266~~283~~
1/3 HP	248.7	30%~~35%~~	829~~714~~	60%~~41%~~	415~~607~~	70%~~66%~~	355~~377~~

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[378] See footnote 370~~293~~ for the explanation of the assumption of 8,273 for walk-in freezers.

[379] 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.

[380] Motor efficiencies: "Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment." Department of Energy. December 2013. Motor efficiencies for the baseline motors are from Table 2.1, which provides peak efficiency ranges for a variety of motors. ECM motor efficiencies is from discussion in section 2.4.3. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf.

Table 173. Compressor Coefficient of Performance Based on Climate and Refrigeration Type (COP_{cooler} or $COP_{freezer}$)

Representative climate city	Summer design dry bulb temperature[381]	EER_{MT}	COP_{cooler}	EER_{LT}	$COP_{freezer}$
Zone 1: Amarillo	98.6	6.18	1.94~~1.88~~	4.77	2.51~~1.46~~
Zone 2: Dallas	101.4	5.91	2.03~~1.77~~	4.56	2.63~~1.37~~
Zone 3: Houston	97.5	6.29	1.91~~1.89~~	4.86	2.47~~1.46~~
Zone 4: ~~McAllen~~Corpus Christi	96.8	6.36	1.89~~1.77~~	4.91	2.44~~1.37~~
Zone 5: El Paso	101.1	5.94	2.02~~1.74~~	4.58	2.62~~1.35~~

Deemed Energy and Demand Savings Tables

The energy and demand savings of ECMs are calculated using a deemed algorithm, based on ~~city~~climate zone, refrigeration temperature, and ~~whether the motors have controls~~presence of motor controls. Therefore, there are no deemed energy or demand tables. 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 estimated useful life (EUL) is 15 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL IDs GrocDisp-FEEvapFanMtr and GrocWlkIn-WEvapFanMtr.[382]

~~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 quantity

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[381] 2017 ASHRAE Handbook: Fundamentals, 0.4% summer design dry-bulb temperatures. http://ashrae-meteo.info/v2.0/.

[382] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

- Motor efficiency
- Motor power rating
- Evaporator fan control type
- Refrigeration ~~temperature~~type (cooler, freezer)

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 174. 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.
v9.0	10/2021	TRM v9.0 update. Updated methodology based on the load shape from original workpaper. Updated EUL reference.

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, with the coefficient of performance variable corresponding to low temperature or medium temperature applications:

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

Equation 141

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

Equation 142

Medium Temperature:

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

Equation 143

Low Temperature:

$$\Delta kWh_{heat} = \Delta kWh_{defrost} \times 0.28 \times COP_{LT}$$

Equation 144

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

Equation 145

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, default = 0.9 kW*[383]

---

[383] Efficiency Vermont TRM, 3/16/2015, p. 170. The total defrost element kW is proportional to the number of evaporator fans blowing over the coil. The typical wattage of the defrost element is 900W per fan. https://www.puc.nh.gov/EESE%20Board/EERS_WG/vt_trm.pdf.

Hours = *Number of hours defrost occurs over a year without defrost controls, 487*[384]

DRF = *Defrost reduction factor—percent reduction in defrosts required per year, see Table 175~~Table 175~~*

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)*~~

COP_{MT} = $12/EER_{MT}$, *the coefficient of performance of compressor in the cooler*

COP_{LT} = $12/EER_{LT}$, *the coefficient of performance of compressor in the freezer*

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

For medium temperature refrigerated cases, the saturated condensing temperature (SCT_{MT}) is calculated as the design dry-bulb temperature plus 15 degrees. For low-temperature refrigerated cases, the SCT_{LT} 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.[385]

For medium temperature compressors, the following equation is used to determine EER_{MT} [Btu/hr/watts] for each hour of the year.

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

Equation 146[386]

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[384] Demand Defrost Strategies in Supermarket Refrigeration Systems, Oak Ridge National Laboratory, 2011. The refrigeration system is assumed to be in operation every day of the year, while savings from the evaporator coil defrost control will only occur during set defrost cycles. This is assumed to be (4) 20-minute cycles per day, for a total of 487 hours. https://info.ornl.gov/sites/publications/files/pub31296.pdf.

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

[386] San Diego Gas & Electric, Work Paper WPSDGENRRN0009: Anti-Sweat Heat (ASH) Controls, "Energy Savings Estimation Methodologies". page 4, Figure 2. August 2012. https://www.sdge.com/sites/default/files/WPSDGENRRN0009%2520Rev%25200%2520Anti-Sweat%2520Heat%2520%2528ASH%2529%2520Controls%2520_0.doc.

Where:

a = *3.75346018700468*

b = *-0.049642253137389*

c = *29.4589834935596*

d = *0.000342066982768282*

e = *-11.7705583766926*

f = *-0.212941092717051*

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

h = *6.80170133906075*

I = *-0.020187240339536*

j = *0.000657941213335828*

PLR = *1/1.15 = 0.87*

SCT_{MT} = $T_{db} + 15$

T_{DB} = *Dry Bulb Temperature*

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

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

Equation 147[387]

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*

---

[387] Ibid.

i = 0.000938305518020252

PLR = 1/1.15 = 0.87

SCT_{LT} = T_{db} +10

T_{DB} = Dry Bulb Temperature

Table 175. Deemed Variables for Energy and Demand Savings Calculations

Climate zone	DRF[388]	~~Eff_{MT}~~COP_{MT}[389]	~~Eff_{LT}~~COP_{LT}[390]
Zone 1: Amarillo	35%	1.94~~1.86~~	2.51~~2.41~~
Zone 2: Dallas		2.03~~1.98~~	2.63~~2.57~~
Zone 3: Houston		1.91~~1.86~~	2.47~~2.41~~
Zone 4: Corpus Christi		1.89~~1.98~~	2.44~~2.57~~
Zone 5: El Paso		2.02~~2.02~~	2.62~~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 estimated useful life (EUL) has been defined for this measure as 10 years.[391]

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[388] Smart defrost kits claim 30-40% savings, of which this value is the midpoint (with up to 44% savings by third party testing by Intertek Testing Service - Smart HVAC: Refrigeration Defrost Kit Aids Troubleshooting (achrnews.com)). https://www.heatcraftrpd.com/contentAsset/raw-data/aee972cd-cbe8-4912-879e-b69aba4d25e9/fileAsset?byInode=true

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

[390] Ibid.

[391] GDS Associates, Inc. (June 2007). *Measure Life Report*. Prepared for The New England State Program Working Group (SPWG). https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf
Additionally, the Pennsylvania TRM Volume 3 Page 162 cites the Vermont TRM, March 16, 2015. Pg. 171: "This is a conservative estimate is based on a discussion with Heatcraft based on the components expected life. https://www.puc.nh.gov/EESE%20Board/EERS_WG/vt_trm.pdf"~~Energy and Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities.~~

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)

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 176. 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.
v9.0	10/2021	TRM v9.0 update. Updated methodology based on the load shape from original workpaper.

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 148

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

Equation 149

Where:

kW_{evap} = *Connected load kW of each evaporator fan, see Table 177~~Table 177~~*

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kW_{circ} = *Connected load kW of the circulating fan, see Table 177~~Table 177~~*

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n_{fans} = *Number of evaporator fans*

DC_{comp} = *Duty cycle of the compressor, see Table 177~~Table 177~~*

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DC_{evap} = *Duty cycle of the evaporator fan, see Table 177~~Table 177~~*

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BF = *Bonus factor for reducing cooling load from replacing the evaporator fan with a lower wattage circulating fan when the compressor is not running, see Table 177~~Table 177~~*

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8,760 = *Annual hours per year*

Table 177. Deemed Variables for Energy and Demand Savings Calculations[392]

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.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 16 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocWlkIn-WEvapFMtrCtrl.[393]

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[392] 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.”

[393] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

~~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).~~[394]

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 (cooler, freezer)
- Refrigeration temperature (low, medium, high)

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 178. 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.
V9.0	10/2021	TRM v9.0 update. Updated EUL reference.

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[394] ~~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. Night covers reduce the cooling load borne by the refrigerated display case's compressor due to a combination of factors: 1) a decrease in convective heat transfer from reduced air infiltration, 2) increased insulation reducing conductive heat transfer, and 3) decreased radiation through the blocking of radiated heat. Additionally, i~~ to decrease the cooling load of the case during the night. I~~t is ~~recommended~~ acceptable ~~that~~ for these film-type covers to have small, perforated holes to decrease ~~the~~ any potential build-up of moisture.

Eligibility Criteria

Any suitable low-emissivity 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 low-emissivity material sold as a night cover. The night cover must be applied for a period of at least 6 hours[395] per day (i.e., average continuous overnight use). ~~Vertical strip curtains may be in use 24 hours per day.~~

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[395] 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~~ for ~~estimate~~ estimating demand and energy savings resulting from the installation of night covers on open low- and medium-temperature, vertical and horizontal refrigerated display cases. Heat transfer components of the display case include infiltration (convection), transmission (conduction), and radiation.

$$\Delta kWh = L \times kWh_{baseline} \times 9\%$$

Equation 150

Where:

ΔkWh = Energy savings

L = Horizontal Linear feet of the low- or medium-temperature refrigerated display case

$kWh_{baseline}$ = Average annual unit energy consumption in terms of kWh/horizontal linear foot/year

9% = The reduction in compressor's electricity use due to the Night Cover's decreasing of convection, conduction, and radiation heat transfer[396]

~~The calculations assume that installing night covers on open display cases will only reduce the infiltration load on the case. At 75 ºF 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.~~[397]
- ~~Infiltration accounts for approximately 24 percent of the total cooling load of open horizontal (coffin or tub style) display cases.~~[398]

~~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%)~~[399]

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[396] Ibid. "Table 1 - Effects of utilizing Heat Reflecting Shields on Refrigeration System Parameters Non-24-hour Supermarket with Shields and Holiday Case versus Base Case"

[397] ~~ASHRAE 2018. Refrigeration Handbook. Retail Food Store Refrigeration and Equipment. Atlanta, Georgia. p. 15.6.~~

[398] ~~Ibid.~~

[399] ~~Ibid., p. 15.26.~~

- ~~50% on horizontal cases.[400]~~

~~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.~~

~~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 (ºF), 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.*~~

~~[400] 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.~~

~~Table 171. Summer Design Dry Bulb Temperaturesby Climate Zone~~

~~Climate zone~~	~~T_{DB} (°F)~~[401]
~~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.~~
- ~~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.~~[402]
- ~~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~~*[403]

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

~~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.~~[404]

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[401] ~~ASHRAE 2009 Handbook Fundamentals.~~

[402] ~~Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.0.2007).~~

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

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

~~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~~

~~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).~~

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

~~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 per-linear-foot energy savings of Night Covers are deemed as 9% (the compressor load reduction from Night Covers defined in the previous section) of the “base-case scenario” efficiency level’s average annual unit energy consumption per horizontal linear foot per display case type from the U.S. Department of Energy’s (DOE) Technical Support Document for Commercial Refrigeration Equipment.[405] Vertical and horizontal *open* equipment types were selected for inclusion given the nature of this measure.

~~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.[406] The deemed energy and demand savings are shown below.~~

---

[405] In 2013, the U.S. DOE conducted an extensive life-cycle cost (LCC) analysis of the commercial refrigeration equipment classes listed in the current federal standard 10 CFR 431.66 to determine average annual unit energy consumption per equipment class. In this analysis, 10,000 separate simulations yielded probability distributions for various parameters associated with each equipment class, among them: the efficiency level in kWh/yr. These efficiency levels were then subject to roll-up calculations to determine market shares of each efficiency level, which were then utilized to compute the average consumption for said efficiency level listed in Table 179~~Table 172~~.
Energy Conservation Standards for Commercial Refrigeration Equipment: Technical Support Document, U.S. Department of Energy, September 2013.
https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cre2_nopr_tsd_2013_08_28.pdf
LCC Summary Statistics: Section 8B2
Average Annual Unit Energy Consumption per Linear Foot by Efficiency Level: Table 10.2.4

~~[406] 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 179. Modeled Deemed Savings for Night Covers for Texas (per Linear Foot)

Temperature[407]	Condensing unit configuration	Equipment family	Average annual energy consumption per linear foot ($kWh_{baseline}$)	ΔkWh	Annual demand savings[408]
Medium (≥32±2 °F)	Remote condensing	Vertical open	1,453	130.77	0
		Horizontal open	439	39.51	0
	Self-contained	Vertical open	2,800	252.00	0
		Horizontal open	1,350	121.50	0
Low (<32±2 °F)	Remote condensing	Vertical open	3,292	296.28	0
		Horizontal open	1,007	90.63	0
	Self-contained	Horizontal open	2,748	247.32	0

~~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

This measure does not have peak demand savings because the Night Covers are applied at night, from approximately midnight to 6:00am.

---

[407] Temperature ranges per commercial refrigeration equipment type are detailed in the current federal standard 10 CFR 431.66. https://www.ecfr.gov/cgi-bin/text-idx?SID=ea9937006535237ca30dfd3e03ebaff2&mc=true&node=se10.3.431_166&rgn=div8

[408] The demand savings for this measure are 0 because energy savings exist at night only.

~~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) is 5 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocDisp-DispCvrs.[409]

~~The EUL has been defined for this measure as 5 years in the DEER 2014 EUL update (EUL ID – GrocDisp-DispCvrs).[410]~~

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 equipment type:
  - Condensing unit configuration (remote condensing or self-contained)
  - Equipment family (vertical or horizontal)
  - Operating temperature (low or medium as defined in Table 179~~Table 179~~)
- ~~Refrigeration temperature~~Horizontal linear feet length of refrigerated case

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

Document Revision History

Table 180. 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.

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[409] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

~~[410] 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.~~

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 and .~~
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.
v9.0	10/2021	TRM v9.0 update. Updated methodology based on the load shape from original workpaper. Updated reference city for climate zone 4. Added “linear feet” for tracking data requirements. Updated EUL reference.

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~~units that are not certified. 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 182~~Table 182~~).

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 181~~Table 181~~.

Table 181. Baseline Energy Consumption[411,412]

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 182~~Table 182~~.

Table 182. Efficient Energy Consumption Requirements[413]

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	

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 181~~Table 181~~ and Table 182~~Table 182~~, based on the volume of the units.

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

[412] V = Interior volume [ft^3] of a refrigerator or freezer (as defined in the Association of Home Appliance Manufacturers Standard HRF1-1979).

[413] 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.

The savings calculations are specified as:

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

Equation 151

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

Equation 152

Where:

kWh_{base} = *Baseline maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 181~~Table 181~~.*

kWh_{ee} = *Efficient maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 182~~Table 182~~.*

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)*[414]

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Deemed Energy and Demand Savings Tables

Table 183. 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

---

[414] 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.

Refrigerator or freezer	Door type	Product volume range (cubic feet)	Average product volume	Energy savings (kWh)	Demand savings (kW)
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 estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocDisp-FixtDoors.[415]

~~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.[416]~~

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)

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[415] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

~~[416] 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

- 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 184. 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. Updated methodology for ENERGY STAR® Version 4.0.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.

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 there is an opening or a ~~the main~~ door is open~~ed~~, reducing the cooling load. This results in a reduced compressor run-time~~, reducing~~ and energy consumption. The measure assumes varying durations for the amount of time the walk-in door is open based on facility type and that the strip curtains cover the entire doorframe.~~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 is a polyethylene strip curtain that is at least 0.06 inches thick, or equivalent. Low temperature strip curtains must be used on low temperature applications (e.g., freezers). The strip curtain must cover the entire area of opening and may not leave gaps between strips or along the doorframe.

~~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.~~The algorithms and assumptions detailed in this section are based on the Regional Technical Forum's methodology[417], which utilizes calculations that determine refrigeration load due to infiltration by air exchange from ASHRAE's Refrigeration Handbook.

Saturation pressure over liquid water, for both the temperature of the refrigerated space which will be treated with strip curtains and the adjacent space, is calculated as follows:

$$\ln\left(P_{ws,Adj}\right) = \frac{C_1}{°R_{Adj}} + C_2 + \left(C_3 * °R_{Adj}\right) + \left(C_4 * °R_{Adj}^2\right) + \left(C_5 * °R_{Adj}^3\right) + \left(C_6 * °R_{Adj}^4\right) + \left(C_7 * \ln\left(°R_{Adj}\right)\right)$$

Equation 153

$$\ln\left(P_{ws,Refrig}\right) = \frac{C_1}{°R_{Refrig}} + C_2 + \left(C_3 * °R_{Refrig}\right) + \left(C_4 * °R_{Refrig}^2\right) + \left(C_5 * °R_{Refrig}^3\right) + \left(C_6 * °R_{Refrig}^4\right) + \left(C_7 * \ln\left(°R_{Refrig}\right)\right)$$

Equation 154

Where:

$P_{ws,Adj}$ = *Saturation Pressure over Liquid Water for the Adjacent Space*

$P_{ws,Refrig}$ = *Saturation Pressure over Liquid Water for the Refrigerated Space*

C_1 = *-1.0214165E+04*

C_2 = *-4.8932428E+00*

C_3 = *-5.3765794E-03*

C_4 = *1.9202377E-07*

C_5 = *3.5575832E-10*

C_6 = *-9.0344688E-14*

C_7 = *4.1635019E+00*

C_8 = *-1.0440397E+04*

C_9 = *-1.1294650E+01*

C_{10} = *-2.7022355E-02*

C_{11} = *1.2890360E-05*

C_{12} = *-2.4780681E-09*

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[417] Regional Technical Forum Strip Curtains UES Measure Workbook (Commercial Grocery Strip Curtain v2.1.xlsx). September 10th, 2019. https://rtf.nwcouncil.org/measure/strip-curtains.

C_{13} = 6.5459673E+00

$°R_{Adj}$ = Adjacent absolute temperature, $t_{DB,Adj} + 459.67$ (see Table 185~~Table 185~~)

$°R_{Refrig}$ = Refrigeration box absolute temperature, $t_{DB,Refrig} + 459.67$ (see Table 185~~Table 185~~)

Saturation pressure over liquid water is then utilized to calculate the humidity ratio of both the refrigerated and adjacent space:

$$W_{Adj} = 0.62198 * \frac{Rh_{Adj} * P_{ws,Adj}}{14.696 - \left(Rh_{Adj} * P_{ws,Adj}\right)}$$

Equation 155

$$W_{Refrig} = 0.62198 * \frac{Rh_{Refrig} * P_{ws,Refrig}}{14.696 - \left(Rh_{Refrig} * P_{ws,Refrig}\right)}$$

Equation 156

Where:

W_{Adj} = Humidity ratio of the adjacent space

W_{Refrig} = Humidity ratio of the refrigerated space

Rh_{Adj} = Relative humidity of the adjacent space (see Table 185~~Table 185~~)

Rh_{Refrig} = Relative humidity of the refrigerated space (see Table 185~~Table 185~~)

The humidity ratio is utilized to compute the air enthalpies for the adjacent and refrigerated space:

$$h_{Adj} = 0.24 * t_{DB,Adj} + \left(W_{Adj} * \left(1061 + \left(0.444 * t_{DB,Adj}\right)\right)\right)$$

Equation 157

$$h_{Refrig} = 0.24 * t_{DB,Refrig} + \left(W_{Refrig} * \left(1061 + \left(0.444 * t_{DB,Refrig}\right)\right)\right)$$

Equation 158

Where:

h_{Adj} = Air enthalpy of the adjacent space

h_{Refrig} = Air enthalpy of the refrigerated space

$t_{DB,Adj}$ = Dry bulb temperature of the adjacent space (see Table 185~~Table 185~~)

$t_{DB,Refrig}$ = Dry bulb temperature of the refrigerated space (see Table 185~~Table 185~~)

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This pair of air enthalpies is then utilized alongside the density factor and the adjacent and refrigerated spaces' air temperature densities and specific volumes to compute the refrigeration load for the fully established flow:

$$v_{Adj} = 0.025210942 * {}^{\circ}R_{Adj} * \left(1 + \left(1.6078 * W_{Adj}\right)\right)$$

Equation 159

$$v_{Refrig} = 0.025210942 * {}^{\circ}R_{Refrig} * \left(1 + \left(1.6078 * W_{Refrig}\right)\right)$$

Equation 160

$$r_{Adj} = \frac{1}{v_{Adj}}$$

Equation 161

$$r_{Refrig} = \frac{1}{v_{Refrig}}$$

Equation 162

$$F_m = \frac{2}{1 + \frac{r_{Refrig}^{\frac{1}{3}}}{r_{Adj}}}^{\frac{3}{2}}$$

Equation 163

$$q = 795.6 * Height * Width * \left(h_{Adj} - h_{Refrig}\right) * r_{Refrig} * \left(1 - \frac{r_{Adj}}{r_{Refrig}}\right)^{\frac{1}{2}} * (32.174 * Height)^{\frac{1}{2}} * F_m$$

Equation 164

Where:

v_{Adj} = *Specific volume of the adjacent space*

v_{Refrig} = *Specific volume of the refrigerated space*

r_{Adj} = *Air temperature density of the adjacent space*

r_{Refrig} = *Air temperature density of the refrigerated space*

F_m = *Density factor*

q = *Refrigeration load for fully established flow*

Height = *Doorway height (see Table 185~~Table 185~~)*

Width = *Doorway width (see Table 185~~Table 185~~)*

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The infiltration between the adjacent and refrigerated space before and after the installation of the strip curtains is a product of the refrigeration load between the two spaces, the time the doorway is assumed to be open per day, the assumed doorway flow factor, and the assumed effectiveness against infiltration post-retrofit:

$$Q_{baseline} = q * \frac{m}{60 * 24} * D_F * (1 - E_{baseline})$$

Equation 165

$$Q_{retrofit} = q * \frac{m}{60 * 24} * D_F * (1 - E_{retrofit})$$

Equation 166

Where:

$Q_{baseline}$ = Baseline total infiltration load

$Q_{retrofit}$ = Total infiltration load post-retrofit

m = Time the door is open per day (see Table 185~~Table 185~~)

D_F = Doorway flow factor (see Table 185~~Table 185~~)

$E_{baseline}$ = Baseline assumed effectiveness against infiltration, 0

$E_{retrofit}$ = Assumed effectiveness against infiltration post-retrofit (see Table 185~~Table 185~~)

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The demand and energy consumption of the compressor associated with each infiltration case are calculated as follows:

$$kW_{baseline} = \frac{Q_{baseline}}{EER * 1000}$$

Equation 167

$$kW_{retrofit} = \frac{Q_{retrofit}}{EER * 1000}$$

Equation 168

$$kWh_{baseline} = kW_{baseline} * EFLH$$

Equation 169

$$kWh_{retrofit} = kW_{retrofit} * EFLH$$

Equation 170

Where:

$kW_{baseline}$ = Baseline demand consumption of the compressor

$kW_{retrofit}$ = Demand consumption of the compressor post-retrofit

$kWh_{baseline}$ = Baseline energy consumption of the compressor

$kWh_{retrofit}$ = Energy consumption of the compressor post-retrofit

EER = EER per facility type (see Table 185~~Table 185~~), which are averaged or weighted across suction group types (see Table 186~~Table 186~~)

FLH = Assumed full-load hours per facility type (see Table 185~~Table 185~~)

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The difference between the baseline and retrofit demand/energy calculations yields whole-door energy savings, which are divided by the area of the doorway to yield per-square foot savings:

$$\Delta kW = kW_{baseline} - kW_{retrofit}$$

Equation 171

$$\Delta kWh = kWh_{baseline} - kWh_{retrofit}$$

Equation 172

$$kW_{Savings} = \frac{\Delta kW}{Height * Width}$$

Equation 173

$$kWh_{Savings} = \frac{\Delta kWh}{Height * Width}$$

Equation 174

Where:

ΔkW = *Whole-door demand savings*

ΔkWh = *Whole-door energy savings*

$kW_{Savings}$ = *Per-square foot demand savings*

$kWh_{Savings}$ = *Per-square foot energy savings*

Several assumptions for independent variables are utilized in the prior equations; these are tabulated in Table 185~~Table 185~~. EER variables are calculated as either the simple or weighted average of representative EERs for refrigeration suction groups that correspond to medium temperature (cooler) or low temperature (freezer) multiplex or standalone units; these are detailed in Table 186~~Table 186~~:

Table 185. Assumed Independent Variables[418]

		Restaurant		Convenience store		Grocery		Refrigerated warehouse	
Variable	Notation	Cooler main door	Freezer main door	Cooler main door	Freezer main door	Cooler main door	Freezer main door	Cooler main door	Freezer main door
Adjacent temperature	t_{DB}	70	67	68	64	71	67	59	n/a
Refrigeration box temperature		39	8	39	5	37	5	28	n/a
Relative Humidity of Adjacent Surroundings	Rh	0.55	0.55	0.55	0.55	0.55	0.55	0.3	n/a
Relative Humidity of Refrigeration Box		0.65	0.4	0.4	0.6	0.5	0.45	0.86	n/a
Height	$Height$	7	7	7	7	7	7	12	n/a
Width	$Weight$	3	3	3	3	3	3	10	n/a
Doorway flow factor	D_F	0.51	0.51	0.51	0.51	0.625	0.625	0.8	n/a
Effectiveness against infiltration – Post-retrofit	$E_{retrofit}$	0.8	0.81	0.79	0.83	0.88	0.88	0.89	n/a
Time door open per day	m	45	38	38	9	132	102	494	n/a
Full-load-hours (FLH) of operation	FLH	5,509	5,509	6,887	6,887	6,482	6,482	2,525	n/a
EER[419]	EER	9.8	4.0	9.8	4.0	11	4.1	9.8	n/a

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[418] Regional Technical Forum Strip Curtains UES Measure Workbook - Assumptions (Commercial Grocery Strip Curtain v2.1.xlsx). September 10th, 2019. https://rtf.nwcouncil.org/measure/strip-curtains.

[419] EER is not an independent variable but is rather dependent on Table 186~~Table 2~~. It is appended here to specify which average corresponds to which facility/refrigeration type.

Table 186. Default EER by System Configuration[420]

System configurations	Representative suction group	Annual average EER value (Btu/hr-W)	Average EER of system configuration (Btu/hr-W)	Straight average EER of temperature (Btu/hr-W)	Grocery store weighted average EER for temperature (Btu/hr-W)
Medium temperature multiplex	Suction group 2075	12.0	11.0	9.8	11.0
	Suction group 2014	12.0			
	Suction group 2185	12.0			
	Suction group 2668	9.2			
Medium temperature standalone	Suction group 2754	7.8	8.4		
	Suction group 894	8.7			
	Suction group 512	8.8			
	Suction group 2043	8.3			
Low temperature multiplex	Suction group 1509	3.7	4.2	4.0	4.1
	Suction group 898	4.1			
	Suction group 2152	4.7			
	Suction group 1753	4.4			
Low temperature standalone	Suction group 996	3.3	3.7		
	Suction group 2518	3.4			
	Suction group 1950	4.6			
	Suction group 2548	3.7			

Table 187. Energy Consumption and Demand for Coolers and Freezers for deemed openings

Variable	Notation	Restaurant		Convenience store		Grocery		Refrigerated warehouse	
		Cooler main door	Freezer main door	Cooler main door	Freezer main door	Cooler main door	Freezer main door	Cooler main door	Freezer main door
Compressor power (kW)	$kW_{baseline}$	0.11	0.54	0.09	0.12	0.44	1.82	8.19	n/a
	$kW_{retrofit}$	0.02	0.10	0.02	0.02	0.05	0.22	0.90	n/a
Deemed annual energy usage	$kWh_{baseline}$	590.72	2,956	626.86	838.78	2,861	11,796	20,678	n/a
	$kWh_{retrofit}$	118.14	561.60	131.64	142.59	343.30	1,416	2,275	n/a

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[420] Regional Technical Forum Strip Curtains UES Measure Workbook - Assumptions (Commercial Grocery Strip Curtain v2.1.xlsx). September 10th, 2019. https://rtf.nwcouncil.org/measure/strip-curtains.

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 188~~Table 188~~.

A standard doorway opening of 7’ x 3’ = 21 square feet may be assumed in lieu of collecting individual door dimensions.

Table 188. Deemed Energy and Demand Savings for Freezers and Coolers~~[421]~~

Savings	Restaurant		Convenience store		Grocery		Refrigerated warehouse	
	Cooler main door	Freezer main door	Cooler main door	Freezer main door	Cooler main door	Freezer main door	Cooler main door	Freezer main door
$kW_{savings}$ $per\ sq.ft.$	0.004	0.021	0.003	0.005	0.018	0.076	0.061	n/a
$kWh_{savings}$ $per\ sq.ft.$	22.50	114.01	23.58	33.15	119.88	494.32	153.36	n/a

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

Claimed Peak Demand Savings

Because the utilization of the strip curtains coincident with the peak demand period is uncertain, an average of the total savings over the operating hours per facility type is used.

~~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) is 4 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocWlkIn-StripCrtn.[422]

~~[421] 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.~~

[422] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

~~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).~~[423]

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)
- Facility type (restaurant, convenience store, grocery store, or refrigerated warehouse)
- Number of openings treated
- Area of each opening

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 189. 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.
v9.0	10/2021	TRM v9.0 update. Added documentation for calculation methodology.

~~[423] 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.~~

		Updated tracking data requirements. Updated EUL reference.