

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.²⁹⁴

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:

- Climate zone
- Manufacturer and model number
- Machine type
 - IMH, RC, or SCU
 - Batch or continuous
- Machine harvest rate
- 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.

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.

²⁹⁴ Department of Energy, Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers, 80 FR 4698, <https://www.federalregister.gov/d/2015-00326/p-4698>.

Document Revision History

Table 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 and 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.²⁹⁵ 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).²⁹⁶ This output is adjusted by population to account for the percentage of sites with electric resistance or heat pump heating.²⁹⁷ Additionally, because output from the OALC is per 1,000 CFM, a CFM per HP ratio²⁹⁸ 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 115

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

Equation 116

Where:

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

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

²⁹⁵ Fisher, D., Swierczyna, R., and Karas, A. (February 2013) Future of DCV for Commercial Kitchens. *ASHRAE Journal*, 48-53.

²⁹⁶ Food Service Technology Center Outdoor Air Load Calculator. No longer available online.

²⁹⁷ 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>.

²⁹⁸ 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
- $Days_{yr}$ = Number of operational days per year, facility specific; if unknown use defaults from Table 157
- 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 for values when there is no dedicated MAU
- $Savings_{interactive/HP}$ = Interactive heating savings per 1,000 CFM of outdoor air; see Table 158
- $PWPLS$ = Probability Weighted Peak Load Share; see Table 159

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 ²⁹⁹	0.650	15	365	0.65
24-hr restaurant/hotel ³⁰⁰	0.631	24	365	0.65
School café with summer ³⁰¹	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

²⁹⁹ Pennsylvania TRM, “3.5.3 High-Efficiency Fan Motors for Walk-In Refrigerated Cases”. Page 369, Table 3-93. June 2016.

³⁰⁰ All values are the average of Hotel Restaurant data from Future of DCV for Commercial Kitchens.

³⁰¹ 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.

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 Share³⁰²

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

³⁰² PWPLS factors are calculated according to the methods described in TRM Volume 1, Section 4.3. The load shape source is the Pacific Northwest National Laboratory Technical Support Document: 50% Energy Savings for Quick-Service Restaurants, Table B.4, Schedule for Kitchen exhaust flow.

Climate zone	Building type	Annual savings (kWh/hp)	
		With dedicated MAU	Without dedicated MAU
3	Casual dining/fast food	4,836	3,572
	24-hr restaurant/hotel	7,368	5,410
	School café with summer	2,985	2,002
	School café without summer	2,144	1,381
4	Casual dining/fast food	5,038	3,775
	24-hr restaurant/hotel	7,787	5,829
	School café with summer	3,144	2,162
	School café without summer	2,261	1,499
5	Casual dining/fast food	4,668	3,404
	24-hr restaurant/hotel	7,034	5,077
	School café with summer	2,801	1,818
	School café without summer	2,023	1,260

Table 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.³⁰³

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly:

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

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Not applicable.

³⁰³ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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

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 spray force in ounce-force (ozf) basis).

Baseline Condition

Effective January 28, 2019, 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 163.³⁰⁴

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

³⁰⁴ Federal Energy Conservation Standard, Code of Federal Regulations, Title 10, Chapter 22, Subchapter D, Part 431, Subpart O, Section §431.266.

High-Efficiency Condition

Following the passing of the Energy Policy Act of 2005, the EPA announced on September 21st, 2005 that it would no longer pursue an ENERGY STAR[®] specification for pre-rinse spray valves.³⁰⁵ 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 a pre-rinse spray valve 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.³⁰⁶

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy and demand savings are calculated using the following algorithms:

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

Equation 117

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

Equation 118

Where:

F_B	=	Baseline flow rate of sprayer (GPM), see Table 163; post-measure flow rate of sprayer (GPM), use actual value
U	=	Water usage duration, see Table 164
T_H	=	Average mixed hot water (after spray valve) temperature (°F), 140.5°F ³⁰⁷

³⁰⁵ "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_Ddecision_Memo_Final.pdf?1e37-d3b8.

³⁰⁶ FEMP Performance Requirements for Federal Purchases of Pre-rinse Spray Valves, Based on ASTM F2324-03: Standard Test Method for Pre-rinse Spray Valves.

³⁰⁷ 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_pl oc=&pg=1&p_tac=&ti=25&pt=1&ch=228&rl=111](https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_pl oc=&pg=1&p_tac=&ti=25&pt=1&ch=228&rl=111).

T_C	=	Average supply (cold) water temperature (°F), 71.4°F ³⁰⁸
Days	=	Annual facility operating days for the applications, see Table 164
C_H	=	Unit conversion for water density: 8.33 lbs/gallon
C_E	=	Unit conversion: 1 BTU = 0.00029308 kWh (1/3412)
Eff_E	=	Recovery efficiency of electric water heater, 0.98 ³⁰⁹
P	=	Hourly peak demand as percent of daily demand probability-weighted peak load share, see Table 165

Table 164. Assumed Variables for Energy and Demand Savings Calculations

Variable	Assumed value
U^{310}	Fast food restaurant: 45 min/day/unit Casual dining restaurant: 105 min/day/unit Institutional: 210 min/day/unit Dormitory: 210 min/day/unit K-12 school: 105 min/day/unit
Days ³¹¹	Fast food restaurant: 360 Casual dining restaurant: 360 Institutional: 360 Dormitory: 270 K-12 school: 193

³⁰⁸ 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>.

³⁰⁹ Recovery efficiency of electric water heaters as listed on the AHRI Directory of Certified Product Performance. <https://www.ahridirectory.org>.

³¹⁰ “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>.

³¹¹ For facilities that operate year-round: assume operating days of 360 days/year; For schools open weekdays except summer: $360 \times (5/7) \times (9/12) = 193$; For dormitories with few occupants in the summer: $360 \times (9/12) = 270$.

Table 165. Probability-Weighted Peak Load Share³¹²

Climate zone	Summer PLS			Winter PLS		
	Full-service restaurant and cafeterias	Fast food	Schools	Full-service restaurants 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.³¹³

Program Tracking Data and Evaluation Requirements

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

- Spray force in ounce-force (ozf)
- Baseline equipment flow-rate
- Retrofit equipment flow-rate
- Building type

³¹² 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 2011/2019. 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.

³¹³ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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.
- 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	10/2021	TRM v9.0 update. General reference checks, updates to input assumptions, and update peak demand savings. Updated EUL reference.

2.4.10 Vacuum-Sealing and 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.³¹⁴ 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.³¹⁵ 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, and 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.³¹⁶

³¹⁴ “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>.

³¹⁵ See Volume 1, Section 4.

³¹⁶ “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 modulates power supplied to the heaters accordingly. DP inside a building is primarily dependent on the moisture content of outdoor ambient air. Because the outdoor DP varies between 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_{d-in}) can be calculated from outdoor dew point (T_{d-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 119³¹⁷

The baseline assumes door heaters are running on an 8,760-hour operating schedule. In the post-retrofit case, the duty for each hourly reading is calculated by assuming a linear relationship between indoor DP and duty cycle for each bin reading. It is assumed that the door heaters will be all off (duty cycle of 0%) at 42.89°F DP and all on (duty cycle of 100%) at 52.87°F DP for a typical supermarket.³¹⁸ Between these values, the door heaters' duty cycle changes proportionally:

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

Equation 120

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 heater³¹⁹ at:

For medium temperature (coolers):

$$kW_{ASH} = 0.109 \text{ per door or } 0.0436 \text{ per horizontal linear foot of door}^{320}$$

Equation 121

³¹⁷ 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.

³¹⁸ Ibid, "Direct ASH Power", page 6.

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

³¹⁹ Pennsylvania TRM, "3.5.6 Controls: Anti-Sweat Heater Controls". page 381, Table 3-101. June 2016. <http://www.puc.pa.gov/pdocs/1350348.docx>. 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/bpdeemedavingsmanuav10_evaluationreport.pdf.

³²⁰ Ibid.

For low temperature (freezers):

$$kW_{ASH} = 0.191 \text{ per door or } 0.0764 \text{ per horizontal linear foot of door}^{321}$$

Equation 122

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

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

Equation 123

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

Equation 124

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,³²² the cooling load contribution from door heaters for each hour of the year can be given by:

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

Equation 125

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_{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 0.87.³²³

³²¹ Ibid.

³²² A Study of Energy Efficient Solutions for Anti-Sweat Heaters. Southern California Edison RTTC. December 1999.

³²³ 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 126³²⁴

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	=	$T_{db} + 15$
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 127³²⁵

Where:

a	=	9.86650982829017
b	=	-0.230356886617629
c	=	22.905553824974

³²⁴ 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.

³²⁵ Ibid.

<i>d</i>	=	0.00218892905109218
<i>e</i>	=	-2.48866737934442
<i>f</i>	=	-0.248051519588758
<i>g</i>	=	-7.57495453950879 × 10 ⁻⁶
<i>h</i>	=	2.03606248623924
<i>i</i>	=	-0.0214774331896676
<i>j</i>	=	0.000938305518020252
<i>PLR</i>	=	1/1.15 = 0.87
<i>SCT_{LT}</i>	=	<i>T_{db}</i> + 10
<i>T_{DB}</i>	=	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 128

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

Equation 129

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

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

Equation 130

Total energy savings is the difference between the baseline and post-retrofit case:

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

Equation 131

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.

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,³²⁶ Table 169 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	0.047	610	0.081
Zone 2: Dallas	232	0.047	413	0.081
Zone 3: Houston	170	0.047	304	0.082
Zone 4: Corpus Christi	131	0.047	234	0.083
Zone 5: El Paso	380	0.047	682	0.084

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.³²⁷

Program Tracking Data and Evaluation Requirements

The below list of 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

³²⁶ <http://texasefficiency.com/index.php/regulatory-filings/deemed-savings>

³²⁷ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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,
https://interchange.puc.texas.gov/Documents/40669_7_736775.PDF.
- 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 Zone³²⁸

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.
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 126 and Equation 127.
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.

³²⁸ <http://texasefficiency.com/index.php/regulatory-filings/deemed-savings>

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 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

$$Demand[kW] = N \times \Delta kW_{peak\ per\ unit} \quad \text{Equation 132}$$

$$\Delta kW_{peak\ per\ unit} = (W_{base} - W_{ee})/1000 \times LF \times DC_{EvapCool} \times \left(1 + \frac{1}{COP_{cooler}}\right) \quad \text{Equation 133}$$

$$Energy[kWh] = N \times \Delta kWh_{per\ unit} \quad \text{Equation 134}$$

$$\Delta kWh_{per\ unit} = \Delta kW_{peak\ per\ unit} \times Hours \times (1 - \%OFF) \quad \text{Equation 135}$$

Freezer

$$Demand[kW] = N \times \Delta kW_{peak\ per\ unit} \quad \text{Equation 136}$$

$$\Delta kW_{peak\ per\ unit} = (W_{base} - W_{ee})/1000 \times LF \times DC_{EvapFreeze} \times \left(1 + \frac{1}{COP_{freezer}}\right) \quad \text{Equation 137}$$

$$Energy[kWh] = N \times \Delta kWh_{per\ unit} \quad \text{Equation 138}$$

$$\Delta kWh_{per\ unit} = \Delta kW_{peak\ per\ unit} \times Hours \times (1 - \%OFF) \quad \text{Equation 139}$$

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

$DC_{EvapFreeze}$	=	<i>Duty cycle of evaporator fan motor for freezer</i>
COP_{cooler}	=	$12/EER_{MT}$, <i>the coefficient of performance of compressor in the cooler</i>
$COP_{freezer}$	=	$12/EER_{LT}$, <i>the coefficient of performance of compressor in the freezer</i>
<i>Hours</i>	=	<i>The annual operating hours are assumed to be 8,760 for coolers and 8,273³²⁹ for walk-ins (see Table 171)</i>
<i>%OFF</i>	=	<i>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%.³³⁰</i>

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 0.87.³³¹

³²⁹ 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% ($8,273 / 8,760 \approx 0.944$), an assumed value which appears in Table 171 for the $DC_{EvapFreeze}$ 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](http://www.greenmountainpower.com/upload/photos/371TRM%20User%20Manual%20No%202013-82-5-protected.pdf).
- Efficiency Maine, Commercial/Industrial and Multifamily Technical Reference Manual 2020.1, July 1, 2019. Page 83, footnote 401.

³³⁰ 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."

³³¹ Work Paper PGEREF108: Anti-Sweat Heat (ASH) Controls. Pacific Gas and Electric Company. May 29, 2009. Assumes 15 percent 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 140³³²

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 141³³³

³³² 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.

³³³ Ibid.

Where:

<i>a</i>	=	9.86650982829017
<i>b</i>	=	-0.230356886617629
<i>c</i>	=	22.905553824974
<i>d</i>	=	0.00218892905109218
<i>e</i>	=	-2.48866737934442
<i>f</i>	=	-0.248051519588758
<i>g</i>	=	-7.57495453950879 × 10 ⁻⁶
<i>h</i>	=	2.03606248623924
<i>i</i>	=	-0.0214774331896676
<i>j</i>	=	0.000938305518020252
<i>PLR</i>	=	1/1.15 = 0.87
<i>SCT_{LT}</i>	=	<i>T_{db}</i> + 10
<i>T_{DB}</i>	=	Dry-bulb temperature

Table 171. Deemed Variables for Energy and Demand Savings Calculations

Variable	Deemed values
<i>W_{base}</i>	See Table 172
<i>W_{ee}</i>	See Table 172
<i>LF</i> ³³⁴	0.9
<i>DC_{EvapCool}</i> ³³⁵	100%
<i>DC_{EvapFreeze}</i> ³³⁶	94.4%
<i>COP_{cooler}</i>	12/ <i>EER_{MT}</i>
<i>COP_{freezer}</i>	12/ <i>EER_{LT}</i>
<i>Hours</i> ³³⁷	8,760 or 8,273
<i>%OFF</i>	0 or 46%

³³⁴ 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>.

³³⁵ Efficiency Maine, Commercial/Industrial and Multifamily Technical Reference Manual 2020.1, July 1, 2019. Page 83, footnote 401.

³³⁶ See footnotes 329 and 335.

³³⁷ See footnote 329 for the explanation of the assumption of 8,273 for walk-in freezers.

Table 172. Motor Sizes, Efficiencies, and Input Watts^{338,339}

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%	30	60%	15	70%	13
1/40 HP (16-23W)	19.5	30%	65	60%	33	70%	28
1/20 HP (37W)	37	30%	123	60%	62	70%	53
1/15 HP (49W)	49.0	30%	163	60%	82	70%	70
1/4 HP	186.5	30%	622	60%	311	70%	266
1/3 HP	248.7	30%	829	60%	415	70%	355

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 ³⁴⁰	EER _{MT}	COP _{cooler}	EER _{LT}	COP _{freezer}
Zone 1: Amarillo	98.6	6.18	1.94	4.77	2.51
Zone 2: Dallas	101.4	5.91	2.03	4.56	2.63
Zone 3: Houston	97.5	6.29	1.91	4.86	2.47
Zone 4: Corpus Christi	96.8	6.36	1.89	4.91	2.44
Zone 5: El Paso	101.1	5.94	2.02	4.58	2.62

Deemed Energy and Demand Savings Tables

The energy and demand savings of ECMs are calculated using a deemed algorithm, based on climate zone, refrigeration temperature, and 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.

³³⁸ 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.

³³⁹ 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>.

³⁴⁰ 2017 ASHRAE Handbook: Fundamentals, 0.4% summer design dry-bulb temperatures. <http://ashrae-meteo.info/v2.0/>.

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 GrocWkln-WEvapFanMtr.³⁴¹

Program Tracking Data and Evaluation Requirements

The below list of 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
- Motor efficiency
- Motor power rating
- Evaporator fan control type
- Refrigeration 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.

³⁴¹ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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

$$\text{Energy [kWh]} = \Delta kWh_{\text{defrost}} + \Delta kWh_{\text{heat}} \quad \text{Equation 142}$$

$$\Delta kWh_{\text{defrost}} = kW_{\text{defrost}} \times DRF \times \text{Hours} \quad \text{Equation 143}$$

Medium temperature:

$$\Delta kWh_{\text{heat}} = \Delta kWh_{\text{defrost}} \times 0.28 \times COP_{MT} \quad \text{Equation 144}$$

Low temperature:

$$\Delta kWh_{\text{heat}} = \Delta kWh_{\text{defrost}} \times 0.28 \times COP_{LT} \quad \text{Equation 145}$$

$$\text{Peak Demand [kW]} = \frac{\Delta kWh}{\text{Hours}} \quad \text{Equation 146}$$

Where:

$\Delta kWh_{\text{defrost}}$ = 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 kW³⁴²

³⁴² 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.

<i>Hours</i>	=	<i>Number of hours defrost occurs over a year without defrost controls, 487³⁴³</i>
<i>DRF</i>	=	<i>Defrost reduction factor—percent reduction in defrosts required per year, see Table 175</i>
<i>0.28</i>	=	<i>Conversion of kW to tons; 3,412 Btuh/kW divided by 12,000 Btuh/ton</i>
COP_{MT}	=	$12/EER_{MT}$, <i>the coefficient of performance of compressor in the cooler</i>
COP_{LT}	=	$12/EER_{LT}$, <i>the coefficient of performance of compressor in the freezer</i>

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 0.87.³⁴⁴

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 147³⁴⁵

Where:

<i>a</i>	=	<i>3.75346018700468</i>
<i>b</i>	=	<i>-0.049642253137389</i>

³⁴³ 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>.

³⁴⁴ Work Paper PGEREF108: Anti-Sweat Heat (ASH) Controls. Pacific Gas and Electric Company. May 29, 2009. Assumes 15 percent oversizing.

³⁴⁵ 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.

<i>c</i>	=	29.4589834935596
<i>d</i>	=	0.000342066982768282
<i>e</i>	=	-11.7705583766926
<i>f</i>	=	-0.212941092717051
<i>g</i>	=	-1.46606221890819 × 10 ⁻⁶
<i>h</i>	=	6.80170133906075
<i>i</i>	=	-0.020187240339536
<i>j</i>	=	0.000657941213335828
<i>PLR</i>	=	1/1.15 = 0.87
<i>SCT_{MT}</i>	=	<i>T_{db}</i> + 15
<i>T_{DB}</i>	=	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 148³⁴⁶

Where:

<i>a</i>	=	9.86650982829017
<i>b</i>	=	-0.230356886617629
<i>c</i>	=	22.905553824974
<i>d</i>	=	0.00218892905109218
<i>e</i>	=	-2.48866737934442
<i>f</i>	=	-0.248051519588758
<i>g</i>	=	-7.57495453950879 × 10 ⁻⁶
<i>h</i>	=	2.03606248623924
<i>i</i>	=	-0.0214774331896676
<i>j</i>	=	0.000938305518020252
<i>PLR</i>	=	1/1.15 = 0.87

³⁴⁶ Ibid.

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

$$T_{DB} = \text{Dry-bulb temperature}$$

Table 175. Deemed Variables for Energy and Demand Savings Calculations

Climate zone	DRF ³⁴⁷	COP _{MT} ³⁴⁸	COP _{LT} ³⁴⁹
Zone 1: Amarillo	35%	1.94	2.51
Zone 2: Dallas		2.03	2.63
Zone 3: Houston		1.91	2.47
Zone 4: Corpus Christi		1.89	2.44
Zone 5: El Paso		2.02	2.62

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.³⁵⁰

³⁴⁷ 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 (achmews.com)). <https://www.heatcraftprd.com/contentAsset/raw-data/aee972cd-cbe8-4912-879e-b69aba4d25e9/fileAsset?bylnode=true>

³⁴⁸ Southern California Edison, Anti-Sweat Heat (ASH) Controls Work Paper WPSCNRRN009 (rev.o.2007).

³⁴⁹ Ibid.

³⁵⁰ 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"

Program Tracking Data and Evaluation Requirements

The below list of 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 equations:

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

Equation 149

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

Equation 150

Where:

kW_{evap}	=	Connected load kW of each evaporator fan, see Table 177
kW_{circ}	=	Connected load kW of the circulating fan, see Table 177
n_{fans}	=	Number of evaporator fans
DC_{comp}	=	Duty cycle of the compressor, see Table 177
DC_{evap}	=	Duty cycle of the evaporator fan, see Table 177
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
8,760	=	Annual hours per year

Table 177. Deemed Variables for Energy and Demand Savings Calculations³⁵¹

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 GrocWkIn-WEvapFMtrCtrl.³⁵²

³⁵¹ The Maine Technical Reference Manual was utilized to determine 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.”

³⁵² DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

Program Tracking Data and Evaluation Requirements

The below list of 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.

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, it is acceptable for these film-type covers to have small, perforated holes to decrease 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 six hours³⁵³ per day (i.e., average continuous overnight use).

³⁵³ 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 for 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 151

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 usage due to the night cover's decreasing of convection, conduction, and radiation heat transfer ³⁵⁴

Deemed Energy and Demand Savings Tables

The per-linear-foot energy savings of night covers are deemed as nine percent (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 US Department of Energy's (DOE) Technical Support Document for Commercial Refrigeration Equipment.³⁵⁵ Vertical and horizontal *open* equipment types were selected for inclusion given the nature of this measure.

³⁵⁴ 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"

³⁵⁵ 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.

Energy Conservation Standards for Commercial Refrigeration Equipment: Technical Support Document, U.S. Department of Energy, September 2013. LCC Summary Statistics: Section 8B2; Average Annual Unit Energy Consumption per Linear Foot by Efficiency Level: Table 10.2.4. https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cre2_nopr_tsd_2013_08_28.pdf.

Table 179. Modeled Deemed Savings for Night Covers for Texas (per Linear Foot)

Temperature ³⁵⁶	Condensing unit configuration	Equipment family	Average annual energy consumption per linear foot ($kWh_{baseline}$)	ΔkWh	Annual demand savings ³⁵⁷
Medium ($\geq 32 \pm 2^\circ F$)	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 ($< 32 \pm 2^\circ F$)	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

Claimed Peak Demand Savings

This measure does not have peak demand savings because the night covers are applied at night, from approximately midnight to 6:00 a.m.

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.³⁵⁸

Program Tracking Data and Evaluation Requirements

The below list of 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)

³⁵⁶ 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

³⁵⁷ The demand savings for this measure are 0 because energy savings exist at night only.

³⁵⁸ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

- Operating temperature (low or medium as defined in Table 179)
- 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.

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.
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
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 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).

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. Baseline Energy Consumption^{359,360}

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	0.75V + 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. Efficient Energy Consumption Requirements³⁶¹

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

The savings calculations are specified as:

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

Equation 152

³⁵⁹ https://www.ecfr.gov/cgi-bin/text-idx?SID=ea9937006535237ca30dfd3e03ebaff2&mc=true&node=se10.3.431_166&rqn=div8.

³⁶⁰ V = Interior volume [ft³] of a refrigerator or freezer (as defined in the Association of Home Appliance Manufacturers Standard HRF1-1979).

³⁶¹ ENERGY STAR® Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency. https://www.energystar.gov/sites/default/files/Commercial%20Refrigerators%20and%20Freezers%20V4%20Spec%20Final%20Version_0.pdf.

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

Equation 153

Where:

- kWh_{base} = Baseline maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 181.
- kWh_{ee} = Efficient maximum daily energy consumption in kWh, based on volume (V) of unit, found in Table 182.
- V = Chilled or frozen compartment volume [ft³] (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)³⁶²

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

³⁶² 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
		$15 \leq V < 30$	19.99	1,726	0.197
		$30 \leq V < 50$	43.13	3,301	0.377
		$V \geq 50$	66.86	5,177	0.591
	Vertical Glass Door	$0 < V < 15$	5.98	1,766	0.202
		$15 \leq V < 30$	19.49	4,321	0.493
		$30 \leq V < 50$	42.29	8,630	0.985
		$V \geq 50$	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.³⁶³

Program Tracking Data and Evaluation Requirements

The below list of 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)

³⁶³ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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.
- 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 door is open, reducing the cooling load. This results in a reduced compressor run-time 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.

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.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The algorithms and assumptions detailed in this section are based on the Regional Technical Forum's methodology³⁶⁴, 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:

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

Equation 154

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

Equation 155

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

³⁶⁴ 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>.

$$\begin{aligned}
C_{13} &= 6.5459673E+00 \\
{}^{\circ}R_{Adj} &= \text{Adjacent absolute temperature, } t_{DB,Adj} + 459.67 \text{ (see Table 185)} \\
{}^{\circ}R_{Refrig} &= \text{Refrigeration box absolute temperature, } t_{DB,Refrig} + 459.67 \\
&\text{(see Table 185)}
\end{aligned}$$

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

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

Equation 156

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

Equation 157

Where:

$$\begin{aligned}
W_{Adj} &= \text{Humidity ratio of the adjacent space} \\
W_{Refrig} &= \text{Humidity ratio of the refrigerated space} \\
Rh_{Adj} &= \text{Relative humidity of the adjacent space (see Table 185)} \\
Rh_{Refrig} &= \text{Relative humidity of the refrigerated space (see Table 185)}
\end{aligned}$$

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

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

Equation 158

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

Equation 159

Where:

$$\begin{aligned}
h_{Adj} &= \text{Air enthalpy of the adjacent space} \\
h_{Refrig} &= \text{Air enthalpy of the refrigerated space} \\
t_{DB,Adj} &= \text{Dry-bulb temperature of the adjacent space (see Table 185)} \\
t_{DB,Refrig} &= \text{Dry-bulb temperature of the refrigerated space (see Table 185)}
\end{aligned}$$

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:

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

Equation 160

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

Equation 161

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

Equation 162

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

Equation 163

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

Equation 164

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

Equation 165

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)
Width	=	Doorway width (see Table 185)

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 166

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

Equation 167

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)
D_F	=	Doorway flow factor (see Table 185)
$E_{baseline}$	=	Baseline assumed effectiveness against infiltration, 0
$E_{retrofit}$	=	Assumed effectiveness against infiltration post-retrofit (see Table 185)

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 168

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

Equation 169

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

Equation 170

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

Equation 171

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), which are averaged or weighted across suction-group types (see Table 186)
FLH	=	Assumed full-load hours per facility type (see Table 185)

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:

$$\Delta kW = kW_{baseline} - kW_{retrofit} \quad \text{Equation 172}$$

$$\Delta kWh = kWh_{baseline} - kWh_{retrofit} \quad \text{Equation 173}$$

$$kW_{savings} = \frac{\Delta kW}{Height * Width} \quad \text{Equation 174}$$

$$kWh_{savings} = \frac{\Delta kWh}{Height * Width} \quad \text{Equation 175}$$

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. 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 185. Assumed Independent Variables³⁶⁵

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
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 is 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 ³⁶⁶	EER	9.8	4.0	9.8	4.0	11	4.1	9.8	N/A

³⁶⁵ 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>.

³⁶⁶ EER is not an independent variable but is rather dependent on Table 186. It is appended here to specify which average corresponds to which facility/refrigeration type.

Table 186. Default EER by System Configuration³⁶⁷

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

³⁶⁷ 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 shown below in 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

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

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.

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 GrocWkIn-StripCrtn.³⁶⁸

Program Tracking Data and Evaluation Requirements

The below list of 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

³⁶⁸ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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. Updated tracking data requirements. Updated EUL reference.

2.5.8 Zero-Energy Doors for Refrigerated Cases Measure Overview

TRM Measure ID: NR-RF-ZE

Market Sector: Commercial

Measure Category: Refrigeration

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

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of zero-energy doors for refrigerated cases. These new zero-energy door designs eliminate the need for anti-sweat heaters to prevent the formation of condensation on the glass surface by incorporating heat reflective coatings on the glass, gas inserted between the panes, non-metallic spacers to separate glass panes, and/or non-metallic frames.

Eligibility Criteria

The efficient equipment must be a standard refrigerated case door with design to eliminate the anti-sweat heaters. This measure cannot be used in conjunction with anti-sweat heat (ASH) controls.

Baseline Condition

The baseline efficiency case is a standard vertical reach-in refrigerated case with anti-sweat heaters on the glass surface of the doors.

High-Efficiency Condition

Eligible high-efficiency equipment is the installation of special doors that eliminate the need for anti-sweat heaters, for low-temperature cases only (below 0 °F). Doors must have either heat-reflective treated glass, be gas-filled, or both.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy savings from the installation of zero energy doors are a result of eliminating the heater (kWh_{ASH}) and the reduction in load on the refrigeration (kWh_{refrig}). These savings are calculated using the following procedures.

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

The instantaneous door heater power (kW_{ASH}) as a resistive load remains constant is per linear horizontal foot of door heater at an assumed 2.5 linear horizontal feet of door:

For medium temperature:

$$kW_{ASH} = 0.109 \text{ per door}^{369}$$

For low temperature:

$$kW_{ASH} = 0.191 \text{ per door}^{370}$$

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

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

Equation 176

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

Equation 177

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,³⁷¹ the cooling load contribution from door heaters can be given by:

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

Equation 178

³⁶⁹ Here, "medium temperature" is equivalent to the categorization "coolers". Pennsylvania TRM, "3.5.6 Controls: Anti-Sweat Heater Controls". page 383, June 2016. https://www.puc.pa.gov/Electric/pdf/Act129/Act129_TRM-2016_Redlined-Final.pdf.

³⁷⁰ Ibid. Here, "low temperature" is equivalent to the categorization "freezers".

³⁷¹ *A Study of Energy Efficient Solutions for Anti-Sweat Heaters*. Southern California Edison RTTC. December 1999.

The compressor power requirements are based on calculated cooling load and energy-efficiency ratios obtained from manufacturers' data. The compressor analysis is limited to the cooling load imposed by the door heaters, not the total cooling load of the refrigeration system.

For medium temperature refrigerated cases, the saturated condensing temperature (SCT) is calculated as the design dry-bulb temperature plus 15 degrees. For low temperature refrigerated cases, the SCT is the design dry-bulb temperature plus 10 degrees. The EER for both medium- and low-temperature applications is a function of SCT and part load ratio (PLR) of the compressor. PLR is the ratio of total cooling load to compressor capacity and is assumed to be a constant or 1/1.15 or approximately 0.87.³⁷²

For medium temperature compressors, the following equation is used to determine the EER_{MT} [Btu/hr/watts]. These values are shown in Table 190.

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

Equation 179³⁷³

Where:

<i>a</i>	=	3.75346018700468
<i>b</i>	=	-0.049642253137389
<i>c</i>	=	29.4589834935596
<i>d</i>	=	0.000342066982768282
<i>e</i>	=	-11.7705583766926
<i>f</i>	=	-0.212941092717051
<i>g</i>	=	-1.46606221890819 × 10 ⁻⁶
<i>h</i>	=	6.80170133906075
<i>i</i>	=	-0.020187240339536
<i>j</i>	=	0.000657941213335828
<i>PLR</i>	=	0.87
<i>SCT</i>	=	<i>T</i> _{DB} + 15

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

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%2520%2520Anti-Sweat%2520Heat%2520%2528ASH%2529%2520Controls%2520_0.doc.

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

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

Equation 180³⁷⁴

Where:

<i>a</i>	=	9.86650982829017
<i>b</i>	=	-0.230356886617629
<i>c</i>	=	22.905553824974
<i>d</i>	=	0.00218892905109218
<i>e</i>	=	-2.4886737934442
<i>f</i>	=	-0.248051519588758
<i>g</i>	=	-7.57495453950879 × 10 ⁻⁶
<i>h</i>	=	2.03606248623924
<i>i</i>	=	-0.0214774331896676
<i>j</i>	=	0.000938305518020252
<i>PLR</i>	=	0.87
<i>SCT</i>	=	$T_{DB} + 10$

Table 190. Coefficients by Climate Zone

Climate zone	T_{DB} ³⁷⁵	SCT_{MT}	SCT_{LT}	EER_{MT}	EER_{LT}
Zone 1: Amarillo	98.6	113.6	108.6	6.18	4.74
Zone 2: Dallas	101.4	116.4	111.4	5.91	4.56
Zone 3: Houston	97.5	112.5	107.5	6.29	4.86
Zone 4: Corpus Christi	96.8	111.8	106.8	6.36	4.91
Zone 5: El Paso	101.1	116.1	111.1	5.94	4.58

Where:

$$T_{DB} = \text{Dry-bulb temperature}$$

³⁷⁴ Ibid.

³⁷⁵ 2017 ASHRAE Handbook: Fundamentals, 0.4% summer design dry-bulb temperatures. <http://ashrae-meteo.info/v2.0/>.

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 181

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

Equation 182

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

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

Equation 183

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

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

Equation 184

While there might be instantaneous demand savings because of the cycling of the door heaters, peak demand savings will only be due to the reduced refrigeration load. Peak demand savings is calculated by the following equation:

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

Equation 185

Table 191. Deemed Energy and Demand Savings Values by Climate Zone and Refrigeration Temperature

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

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocDisp-ZeroHtDrs.³⁷⁶

Program Tracking Data and Evaluation Requirements

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

- Refrigeration temperature range

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669 provides energy and demand savings and measure specifications
- PUCT Docket 36779 provides EUL values for Zero Energy Doors

Relevant Standards and Reference Sources

- DEER 2014 EUL update

Document Revision History

Table 192. Nonresidential Zero-Energy Doors for Refrigerated Cases Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. Updated savings methodology to be consistent with the door heater controls measure.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. Clarified energy and demand savings are in kilowatt/door rather than kilowatt/feet. Updated EUL reference.

³⁷⁶ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

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

TRM Measure ID: NR-RF-DG

Market Sector: Commercial

Measure Category: Refrigeration

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

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

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

Measure Description

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

Eligibility Criteria

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

Baseline Condition

The baseline standard for this measure is a walk-in or reach-in cooler or freezer with worn-out, defective door gaskets with at least six inches of damage for reach-in units and at least two feet of damage for walk-in units.³⁷⁷ An average baseline gasket efficacy³⁷⁸ of 90 percent is assumed for this measure.

³⁷⁷ Musgrave, Dwight. Emerson Design Services Network. "Study of Typical Gasket Deterioration", Feb 27, 2008, Slide 24. <https://slideplayer.com/slide/4525301/>.

³⁷⁸ Gasket efficacy is defined as the ratio of the gasket length that was removed by the installers to the gasket length that was replaced. A 90 percent gasket efficacy translates to an average of 10 percent of missing, badly damaged or ineffective gasket by length replaced.

High-Efficiency Condition

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

Energy and Demand Savings Methodology

The energy savings assumptions are based on DEER 2005 analysis performed by Southern California Edison (SCE) and an evaluation of a Pacific Gas and Electric (PG&E) direct install refrigeration measures for program year 2006-2008.^{379,380} The results from the PG&E evaluation were used as the foundation for establishing the energy savings for the refrigeration gasket measures. The energy savings achievable for new gaskets replacing baseline gaskets were found during this study to be dependent almost entirely on the leakage through the baseline gaskets. Therefore, the energy savings attributable to door gaskets were derived for various scenarios regarding baseline gasket efficacies and are shown in Table 193 below.

Table 193. Energy Savings Achievable for New Gaskets Replacing Baseline Gaskets of Various Efficacies (per Linear Foot of Installed Door Gasket)³⁸¹

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

As the PG&E analysis was performed in California with different climate zones as compared to those in Texas, an analysis was conducted to develop an adjustment factor to associate the savings in the table above to Texas anticipated results. The PG&E study could not be used to determine these effects, as insufficient climate zones were researched. Therefore, the SCE study was utilized as savings in this study were determined for each of the 16 climate zones in California and were similar³⁸² to those assessed within the PG&E results at 90 percent efficacy. A comparison was completed between the SCE energy savings and the typical meteorological year 3 (TMY3) data³⁸³ to establish a cooling degree day (CDD) correlation across the 16 California climate zones. Figure 3 provides a summary comparison for coolers and Figure 4 for freezers.

³⁷⁹ Southern California Edison (SCE). WPCSNRRN0013—Door Gaskets for Glass Doors of Medium and Low Temperature Reach-in Display Cases and Solid Doors of Reach-in Coolers and Freezers. 2007.

³⁸⁰ Commercial Facilities Contract Group (ComFac), 2006-2008 Direct Impact Evaluation Study ID: PUC0016.01. February 18, 2010.

http://www.calmac.org/publications/comfac_evaluation_v1_final_report_02-18-2010.pdf.

³⁸¹ Ibid., Table 5-3.

³⁸² The SCE ex-ante savings as reported in the PG&E report were 10.2 and 21.7 kWh/linear foot for coolers and freezers respectively.

Commercial Facilities Contract Group (ComFac), 2006-2008 Direct Impact Evaluation Study ID: PUC0016.01. February 18, 2010. Table 5-3.

http://www.calmac.org/publications/comfac_evaluation_v1_final_report_02-18-2010.pdf.

Modeled savings as reported in the SEC report for climate zone 4 were approximately 6 and 15 kWh/linear foot for coolers and freezers respectively.

³⁸³ <http://texasefficiency.com/index.php/regulatory-filings/deemed-savings>

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

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

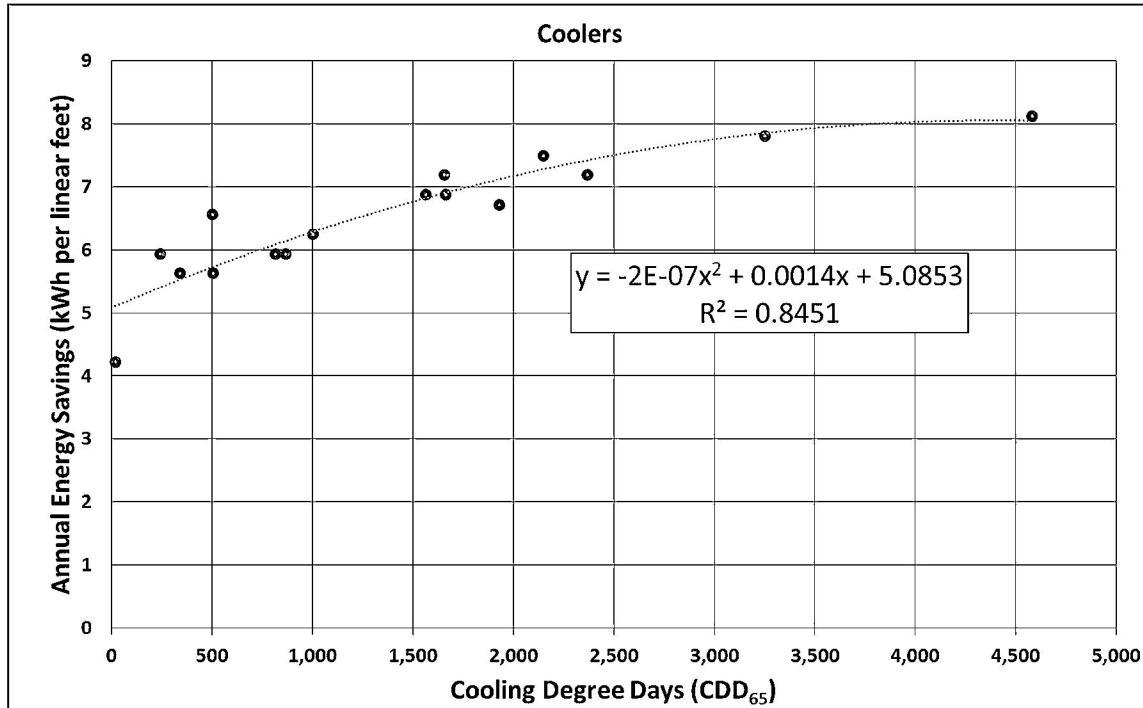
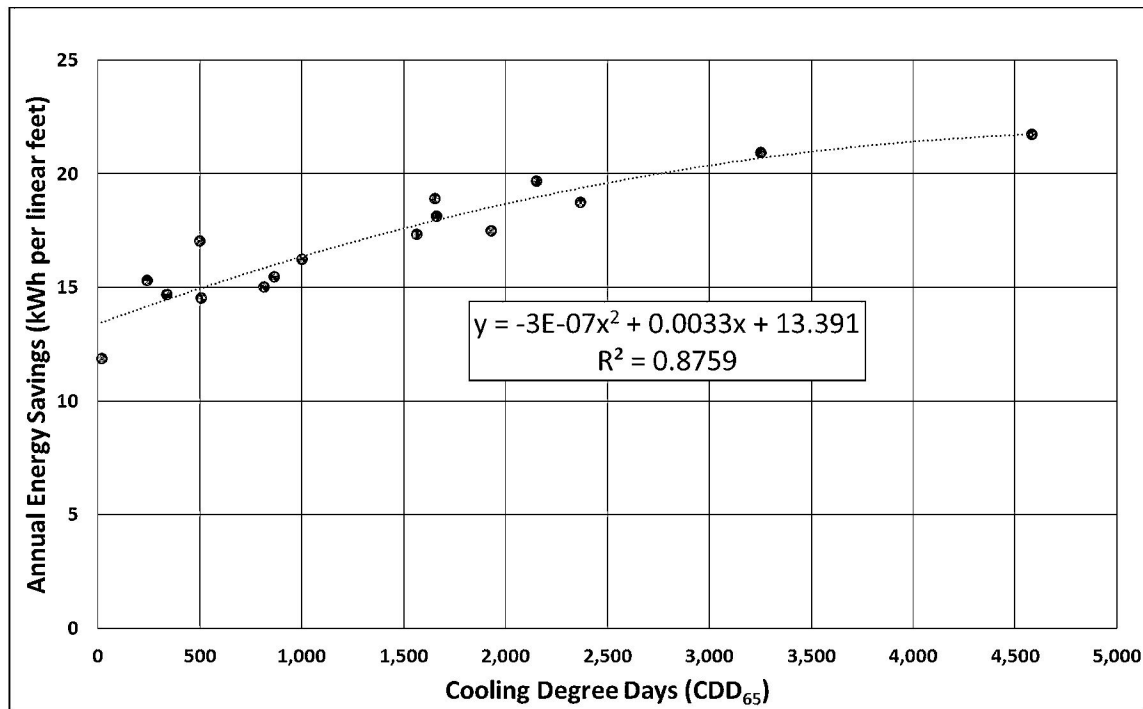


Figure 4. Comparison of Projected Annual Energy Savings to Cooling Degree Days for All 16 California Climate Zones for Reach-In Display Cases (Freezers)



These correlations were used to adjust the energy savings and TMY3 CDDs in California to TMY3 CDDs in Texas to determine an average energy savings of 7.4 and 20.0 kWh/linear feet for coolers and freezers in Texas. Comparing the average energy savings between California and Texas, the CDD adjustment results in a 113 percent adjustment factor for coolers and a 117 percent adjustment factor for freezers. For simplicity, an average adjustment factor of 115 percent (the midpoint of 113% and 117% TX vs. CA Energy Savings values) was applied to the PG&E results at 90 percent efficacy (as shown in Table 193 above), resulting in Texas-based annual energy savings values for coolers of 3.5 kWh/linear feet and freezers of 26.5 kWh/linear feet. These results are summarized in Table 194 below.

Table 194. Energy Savings Achievable for New Gaskets Replacing Baseline Gaskets of Various Efficacies (per Linear Foot of Installed Door Gasket)

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

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

Savings Algorithms and Input Variables

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

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

Equation 186

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

Equation 187

Where:

$\Delta kWh/ft$ = Annual energy savings per linear foot of gasket (see Table 195)

L = Total gasket length (ft.)

Deemed Energy and Demand Savings Tables

Table 195. Deemed Energy and Demand Savings per Linear Foot of Installed Door Gasket

Refrigerator type	$\Delta kW/ft$	$\Delta kWh/ft$
Walk-in or reach-in cooler	0.0004	3.5
Walk-in or reach-in freezer	0.0030	26.5

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 3 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GrocDisp-FixtDrGask.³⁸⁴

Program Tracking Data and Evaluation Requirements

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

- Building type (convenience store, supermarket, restaurant, refrigerated warehouse)
- Refrigerator type (walk-in or reach-in cooler or freezer)
- Length of ineffective gasket (ft.)
- Primary reason for ineffectiveness (missing, torn through both sides, rotted/dry, poor fit/shrink, or other)
- Total length of installed gasket (ft.)
- Presence of existing gasket (yes/no)

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

- TMY3 Hourly Weather Data by Climate Zone³⁸⁵

³⁸⁴ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

³⁸⁵ <http://texasefficiency.com/index.php/regulatory-filings/deemed-savings>

Document Revision History

Table 196. Nonresidential Door Gaskets for Walk-In and Reach-In Coolers and Freezers Revision History

TRM version	Date	Description of change
v6.0	10/2018	TRM v6.0 origin.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Updated EUL reference.

2.5.10 High-Speed Doors for Cold Storage Measure Overview

TRM Measure ID: NR-RF-HS

Market Sector: Commercial

Measure Category: Refrigeration

Applicable Building Types: Commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Algorithms

Savings Methodology: Algorithms

Measure Description

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

Eligibility Criteria

Eligible equipment includes high-speed doors with a minimum opening rate of 32 inches per second, a minimum closing rate of 24 inches per second, and a means to automatically reclose the door, as defined by the Door and Access Systems Manufacturers' Association, International (DASMA).³⁸⁶ The high-speed doors must be installed for access to a cold storage area either from exterior conditions, such as a loading dock, or from a conditioned area, such as a non-refrigerated warehouse.

Baseline Condition

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

High-Efficiency Condition

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

³⁸⁶ DASMA Standard Specification for High Speed Doors and Grilles, definition 2.6 for High Speed Door. <https://www.dasma.com/wp-content/uploads/pubs/Standards/DASMA403.pdf>.

Energy and Demand Savings Methodology

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

Savings Algorithms and Input Variables

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

Equation 188

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

Equation 189

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

Equation 190

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

Equation 191

Where:

<i>w</i>	=	<i>Width of the door opening (ft.)</i>
<i>h</i>	=	<i>Height of the door opening (ft.)</i>
<i>energy factor</i>	=	<i>The outcome of Equation 189 based on climate zone and cold storage application, see Table 197 and Table 198</i>
<i>demand factor</i>	=	<i>The outcome of Equation 191 based on climate zone and cold storage application, see Table 199, Table 200, and Table 201</i>
<i>hours</i>	=	<i>Operating hours, 3,798³⁸⁷</i>
3,790	=	<i>Constant³⁸⁸</i>

³⁸⁷ Operating hours taken from TRM Volume 3, Table 8, hours for refrigerated warehouse.

³⁸⁸ From ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, equation 16.

$\frac{q_s}{A}$	=	Sensible heat load of infiltration air per square foot of door opening, ton/ft ² , see Table 202
R_s	=	Sensible heat ratio of the infiltration air heat gain, see Table 203
ΔD_t	=	Change in percent of time the doorway is open, 0.33 ³⁸⁹
D_f	=	Doorway flow factor, varies based on temperature delta between cold room and infiltration air, 0.8 for delta T ≥ 20°F, 1.1 for delta T < 20°F ³⁹⁰
ΔE	=	Change in door effectiveness, 0.2 ³⁹¹
COP	=	Coefficient of performance, assume 2.8 COP ³⁹²
3,412	=	Conversion factors

Table 197. High-Speed Doors—Energy Factors for Door to Unconditioned Area

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

Table 198. High-Speed Doors—Energy Factors for Door to Conditioned Area

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

Table 199. High-Speed Doors—Summer and Winter Demand Factors for Door to Conditioned Area

Cold room temperature	All temperatures
All climate zones	1.0

³⁸⁹ From ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, simplification of equation 17 notes; assume baseline door open-close time is 15 seconds, and high-speed door open-close time is 10 seconds, for a difference in percent of time the door is open of (15-10)/15 = 0.33.

³⁹⁰ ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, equation 17 notes.

³⁹¹ ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, simplification of equation 17 notes. ASHRAE provides a range of doorway effectiveness, stating 0.95 for newly installed doors though that may quickly decrease to 0.8 or 0.85 depending on door use frequency and maintenance. Air curtain effectiveness ranges from very poor to more than 0.7. The input assumptions for this measure are conservatively estimated for baseline door effectiveness of 0.7 and high-speed door effectiveness of 0.9.

³⁹² Air cooled chiller efficiency from IECC 2009.

Table 200. High-Speed Doors—Summer Demand Factors for Door to Unconditioned Area

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

Table 201. High-Speed Doors—Winter Demand Factors for Door to Unconditioned Area

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

Table 202. High-Speed Doors— $\frac{q_s}{A}$, Sensible Heat Load of Infiltration Air³⁹³

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

³⁹³ From ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, figure 9. Values in table are summarized to reflect average annual and summer and winter peak infiltration air Temperatures. Where infiltration air Temperatures are not shown on ASHRAE figure 9, $\frac{q_s}{A}$ is estimated by extrapolation. Values for infiltration air temperature of 75°F are used to calculate energy and demand factors for doorways between cold room and conditioned space.

Table 203. High-Speed Doors— R_s , Sensible Heat Ratio of Infiltration Air³⁹⁴

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

Deemed Energy and Demand Savings Tables

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

Claimed Peak Demand Savings

The utilization of the high-speed doors coincident with the peak demand period is uncertain, an average of the total savings over the operating hours per facility type is used (the absence of *hours* in Equation 191 implies Equation 188 can be divided by *hours* to yield *kW savings*).

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

Measure Life and Lifetime Savings

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

³⁹⁴ Sensible heat ratio determined from psychrometric chart, using values for the air properties of dry bulb Temperature and relative humidity. Relative humidity of the cold room is estimated at 90 percent based on ASHRAE 2018 Refrigeration Handbook, Chapter 24-4, Table 9. Energy factor values for unconditioned space are the average annual values between the expected operating hours of 8 a.m. to 6 p.m. using TMY3 data. Demand factor values for unconditioned space are taken using the highest probability temperatures from TRM Volume 1 and their associated relative humidity from TMY3 data. Energy and demand factor values for conditioned space assume conditioned air temperature of 75°F and 45 percent RH.

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly:

- Climate zone
- Cold room temperature
- Doorway opening location (conditioned or unconditioned)
- Door quantity
- Width and height of door(s)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 204. Nonresidential High-Speed Doors for Cold Storage Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.
v9.0	10/20221	TRM v9.0 update. General reference checks and text edits.

2.6 NONRESIDENTIAL: WATER HEATING

2.6.1 Central Domestic Hot Water Controls Measure Overview

TRM Measure ID: NR-WH-DC

Market Sector: Commercial

Measure Category: Water Heating

Applicable Building Types: Multifamily, lodging, nursing homes, dormitories, prisons, offices, and education

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

Central domestic hot water (DHW) systems with recirculation pumps distribute hot water continuously throughout the building to the end-users. DHW pump controls save energy by reducing the operating hours of the circulation pumps and reducing thermal losses throughout the distribution system.

Eligibility Criteria

This measure applies to commercial and lodging applications with a central DHW system that includes a pump to circulate hot water through the distribution loop. To be eligible for these deemed savings, the control strategy must include operating the pump only when the hot water circulation loop temperature drops below a specific value, and there is hot water demand called by an end-user.

Baseline Condition

The baseline condition is a new or existing central DHW system with a circulation pump that operates continuously.

High-Efficiency Condition

The measure requires the installation of a pump controller with a combination temperature and demand control method.

Energy and Demand Savings Methodology

Savings for central DHW controls come from circulation pump controller runtime reduction and thermal distribution loss reduction. Pump runtime savings apply to all projects, while thermal distribution loss reduction applies only to lodging sites with an electrically fueled water heater.

Savings Algorithms and Input Variables

Circulation Pump Savings Algorithm

$$\text{Annual Pump Energy Savings [kWh]} = kW_{\text{pump}} \times (\text{Pump}_{\% \text{On}_{\text{base}}} - \text{Pump}_{\% \text{On}_{\text{eff}}}) \times \text{Hours}$$

Equation 192

$$\text{Pump Demand Savings [kW]} = \text{Annual Pump Energy Savings} \times \text{PLS}$$

Equation 193

Where:

kW_{pump}	=	The demand used by the circulation pump, obtained from the project site; if unknown, assume 0.075 kW
$\text{Pump}_{\% \text{On}_{\text{base}}}$	=	Baseline pump operation as percentage of time, 100%
$\text{Pump}_{\% \text{On}_{\text{eff}}}$	=	Efficient pump operation as percentage of time, 7% ³⁹⁵
Hours	=	Hours per year = 8,760
PLS	=	Probability-weighted peak load share, Table 205

Table 205. Central DHW Controls—Probability Weighted Peak Load Share³⁹⁶

Building type	Commercial		Lodging ³⁹⁷	
	Summer peak	Winter peak	Summer peak	Winter peak
Zone 1	0.00016	0.00011	0.00012	0.00015
Zone 2	0.00017	0.00011	0.00012	0.00014
Zone 3	0.00016	0.00011	0.00012	0.00015

³⁹⁵ A 93 percent pump runtime reduction is assumed based on the average runtime reduction of field studies conducted at multiple sites: “Evaluation of New DHW System Controls in Hospitality and Commercial Buildings,” Minnesota Department of Commerce, average reduction of 87 percent; and “Energy-Efficiency Controls for Multifamily Domestic Hot Water Systems,” New York State Energy Research and Development Authority, average reduction of 99 percent.

³⁹⁶ 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 Water and Process Heating. Peak Season, Peak Weekday values used for summer calculations. Off Peak Season, Peak Weekday values used for winter calculations. <http://loadshape.epri.com/enduse>.

³⁹⁷ For the purposes of this measure, the lodging building type applies to all buildings where lodging takes place, including multifamily, hotels, nursing homes, dormitories, prisons, and similar.

Building type	Commercial		Lodging ³⁹⁷	
	Summer peak	Winter peak	Summer peak	Winter peak
Zone 4	0.00016	0.00011	0.00012	0.00015
Zone 5	0.00018	0.00011	0.00012	0.00014

Thermal Distribution Savings Algorithm

$$\text{Annual Thermal Energy Savings [kWh]} = \# \text{ Units} \times kWh_{\text{reference}} \times \text{HDD Adjustment}$$

Equation 194

$$\text{Thermal Demand Savings [kW]} = \text{Annual Thermal Energy Savings} \times \text{PLS}$$

Equation 195

Where:

- # Units = The number of dwelling units at the project site
- $kWh_{\text{reference}}$ = Annual kWh energy savings from reference study, see Table 206.
- HDD Adjustment = Climate adjustment for Texas heating degree days, see Table 207.
- PLS = Probability-weighted peak load share, see Table 205

Table 206. Central DHW Controls—Reference kWh by Water Heater and Building Type³⁹⁸

Water heater type	Electric resistance		Heat pump	
	Low rise	High rise	Low rise	High rise
kWh reference	539	332	211	130

Table 207. Central DHW Controls—HDD Adjustment Factors³⁹⁹

Climate zone	HDD adjustment
Zone 1	1.9
Zone 2	1.1
Zone 3	0.7
Zone 4	0.5
Zone 5	1.1

³⁹⁸ Reference kWh are the annual energy savings per dwelling unit from the Southern California Edison Company Work Paper SCE13WP002, Demand Control for Centralized Water Heater Recirculation Pump for California Climate Zone 13.

³⁹⁹ HDD Adjustment factors for DHW controls are derived by dividing the HDD for each Texas climate zone by the HDD from the reference climate zone (California Climate Zone 13).

Deemed Energy Savings Tables

Table 208 presents the energy savings (kWh) for a range of pump sizes for all climate zones. The deemed savings are provided for convenience, but the algorithm may be used for pump sizes that differ from the assumed wattage listed in the tables.

Table 208. Central DHW Controls—Annual kWh Circulation Pump Savings

Pump size (watts)	Assumed wattage	Annual pump kWh savings
≤ 50	50	407
50 < watts < 100	75	611
100 ≤ watts < 150	125	1,018
≥ 150	150	1,222

Table 209 presents the thermal energy savings (kWh) per dwelling unit for all climate zones. Thermal energy savings only apply to lodging building types where lodging takes place (multifamily, hotels, nursing homes, dormitories, prisons, and similar). For commercial applications, please follow a custom approach.

Table 209. Central DHW Controls—Annual kWh Thermal Distribution Savings per Dwelling Unit

Climate zone	Electric resistance		Heat pump	
	Low rise	High rise	Low rise	High rise
Zone 1	1,007	620	395	243
Zone 2	566	349	222	137
Zone 3	372	229	146	90
Zone 4	249	153	98	60
Zone 5	590	364	231	143

Deemed Summer and Winter Demand Savings Tables

The following tables present the peak demand impacts for all climate zones.

Table 210. Central DHW Controls—Peak Demand kW Circulation Pump Savings

Pump size	Climate zone	Commercial		Lodging	
		Summer peak kW	Winter peak kW	Summer peak kW	Winter peak kW
≤ 50	Zone 1	0.065	0.045	0.049	0.061
	Zone 2	0.069	0.045	0.049	0.057
	Zone 3	0.065	0.045	0.049	0.061
	Zone 4	0.065	0.045	0.049	0.061
	Zone 5	0.073	0.045	0.049	0.057

Pump size	Climate zone	Commercial		Lodging	
		Summer peak kW	Winter peak kW	Summer peak kW	Winter peak kW
50 < watts < 100	Zone 1	0.098	0.067	0.073	0.092
	Zone 2	0.104	0.067	0.073	0.086
	Zone 3	0.098	0.067	0.073	0.092
	Zone 4	0.098	0.067	0.073	0.092
	Zone 5	0.110	0.067	0.073	0.086
100 ≤ watts < 150	Zone 1	0.163	0.112	0.122	0.153
	Zone 2	0.173	0.112	0.122	0.143
	Zone 3	0.163	0.112	0.122	0.153
	Zone 4	0.163	0.112	0.122	0.153
	Zone 5	0.183	0.112	0.122	0.143
≥ 150	Zone 1	0.196	0.134	0.147	0.183
	Zone 2	0.208	0.134	0.147	0.171
	Zone 3	0.196	0.134	0.147	0.183
	Zone 4	0.196	0.134	0.147	0.183
	Zone 5	0.220	0.134	0.147	0.171

Table 211. Central DHW Controls—Peak Demand kW Thermal Savings per Dwelling Unit

Climate zone	Summer peak				Winter peak			
	Electric resistance		Heat pump		Electric resistance		Heat pump	
	Low rise	High rise	Low rise	High rise	Low rise	High rise	Low rise	High rise
Zone 1	0.12	0.07	0.05	0.03	0.15	0.09	0.06	0.04
Zone 2	0.07	0.04	0.03	0.02	0.08	0.05	0.03	0.02
Zone 3	0.04	0.03	0.02	0.01	0.06	0.03	0.02	0.01
Zone 4	0.03	0.02	0.01	0.01	0.04	0.02	0.01	0.01
Zone 5	0.07	0.04	0.03	0.02	0.08	0.05	0.03	0.02

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

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 WtrHt-Timeclock.⁴⁰⁰

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:

- Climate zone
- Circulation pump wattage
- Building type: commercial or lodging
- Building size: Low rise or high rise
- Water heater type: electric resistance or heat pump
- If lodging, number of lodging units at project site

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- DEER 2014 EUL update.

Document Revision History

Table 212. Nonresidential Central DHW Controls 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.

⁴⁰⁰ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

2.6.2 Showerhead Temperature Sensitive Restrictor Valves Measure Overview

TRM Measure ID: NR-WH-SV

Market Sector: Commercial

Measure Category: Water Heating

Applicable Building Types: Lodging

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure consists of installing a temperature sensitive restrictor valve (TSRV)⁴⁰¹ between the existing shower arm and showerhead. The valve restricts hot water flow through the showerhead once the water reaches a set temperature (generally 95°F) to prevent water from going down the drain prior to the user entering the shower, thereby eliminating behavioral waste.

Eligibility Criteria

These deemed savings are for temperature sensitive restrictor valves installed in new construction or as a retrofit measure in commercial lodging applications. Buildings must have electrically-fueled hot water to be eligible for this measure.

Baseline Condition

The baseline condition is the commercial lodging shower arm and standard (2.5 gpm) showerhead without a temperature sensitive restrictor valve installed.

High-Efficiency Condition

The high-efficiency condition is a temperature sensitive restrictor valve installed on a commercial lodging shower arm and showerhead with either a standard (2.5 gpm) or low-flow (2.0, 1.75, or 1.5 gpm) showerhead.

⁴⁰¹ A temperature-sensitive restrictor valve is any device that uses water temperature to regulate water flow in showers.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Estimated Hot Water Usage Reduction

To determine gallons of behavioral waste (defined as hot water that goes down the drain before the user enters the shower) per year, the following formula was used:

$$\text{Annual Showerhead Behavioral Waste} = SHFR \times BW \times n_s \times 365 \frac{\text{days}}{\text{year}} \times \frac{OCC}{n_{SH}}$$

Equation 196

Where:

<i>SHFR</i>	=	<i>Showerhead flow rate, gallons per minute (gpm) (see Table 213)</i>
<i>BW</i>	=	<i>Behavioral waste, minutes per shower (see Table 213)</i>
<i>n_s</i>	=	<i>Number of showers per occupied room per day (see Table 213)</i>
<i>365</i>	=	<i>Constant to convert days to years (see Table 213)</i>
<i>OCC</i>	=	<i>Occupancy rate (see Table 213)</i>
<i>n_{SH}</i>	=	<i>Number of showerheads per room (see Table 213)</i>

Applying the formula to the values used for Texas from Table 213 returns the following values for baseline behavioral waste in gallons per showerhead per year:

$$\text{Showerhead (2.5 GPM): } 2.5 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} = 1,838 \text{ gal}$$

$$\text{Showerhead (2.0 GPM): } 2.0 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} = 1,471 \text{ gal}$$

$$\text{Showerhead (1.75 GPM): } 1.75 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} = 1,287 \text{ gal}$$

$$\text{Showerhead (1.5 GPM): } 1.5 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} = 1,103 \text{ gal}$$

Gallons of hot water saved per year can be found by multiplying the baseline behavioral waste gallons per year by the percent of hot water from Table 213.

$$\text{Gallons of hot water saved per year} = \text{Annual Behavioral Waste} \times \text{HW\%}$$

Equation 197

Where:

$$\text{HW\%} = \text{Hot water percentage (see Table 213)}$$

$$\text{Gallons of hot water saved per year (2.5 GPM): } 1,838 \times 0.825 = 1,516 \text{ gal}$$

$$\text{Gallons of hot water saved per year (2.0 GPM): } 1,471 \times 0.825 = 1,213 \text{ gal}$$

$$\text{Gallons of hot water saved per year (1.75 GPM): } 1,287 \times 0.825 = 1,062 \text{ gal}$$

$$\text{Gallons of hot water saved per year (1.5 GPM): } 1,103 \times 0.825 = 910 \text{ gal}$$

Table 213. Showerhead TSRVs—Hot Water Usage Reduction

Description	2.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
Average behavioral waste (minutes per shower) ⁴⁰²	1.742			
Showers/occupied room/day ⁴⁰³	1.756			
Occupancy rate ⁴⁰⁴	65.9%			
Showerheads/room ⁴⁰⁵	1.0			
Behavioral waste/showerhead/year (gal)	1,838	1,471	1,287	1,103
Percent hot water ⁴⁰⁶	80-85%, or 82.5% on average			
Hot water saved/year (gal)	1,516	1,213	1,062	910

⁴⁰² Shower Stream 2019 pilot study based on 747 metered shower events with an average duration of 104.51 seconds. This represents a subset of the total data set, as this value was not recorded for the entire data set. This assumption will be updated in future years to reflect additional pilot study data.

⁴⁰³ Shower Stream 2019 pilot study based on 2,406 metered shower events. Weighted average calculated by dividing total shower events by total number of devices. This assumption will be updated in future years to reflect additional pilot study data.

⁴⁰⁴ 2001-2019 U.S. hotel occupancy rates from Statista. <https://www.statista.com/statistics/200161/us-annual-accomodation-and-lodging-occupancy-rate/>. Used average of last 5 years (2015-2019).

⁴⁰⁵ Assuming industry standard for standard one-bathroom rooms.

⁴⁰⁶ Average percent hot water from (Lutz 2004) Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems and (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$\text{Energy Savings per TSRV} = \frac{\rho \times C_p \times V \times (T_{\text{SetPoint}} - T_{\text{SupplyAverage}})}{RE \times 3,412}$$

Equation 198

Where:

ρ	=	Water density, 8.33 lbs/gallon
C_p	=	Specific heat of water, 1 Btu/lb°F
V	=	Gallons of hot water saved per year per showerhead (see Table 213)
T_{SetPoint}	=	Water heater setpoint: 120°F ⁴⁰⁷
T_{Supply}	=	Average supply water temperature (see Table 214)
RE	=	Recovery Efficiency (or in the case of heat pump water heaters, COP); if unknown, use 0.98 as a default for electric-resistance water heaters, or 2.2 for heat-pump water heaters. ⁴⁰⁸
3,412	=	Constant to convert from Btu to kWh

Demand Savings Algorithms

Demand savings are calculated by substituting the average supply temperature for the average seasonal temperature, multiplying by a coincidence factor equivalent to the daily fraction hot water use during the weighted peak hour for each climate zone (see Volume 1, Section 4), and dividing by 365 days/year.

$$\text{Demand Savings per TSRV} = \frac{\rho \times C_p \times V \times (T_{\text{SetPoint}} - T_{\text{SupplySeasonal}})}{RE \times 3,412 \times 365} \times CF$$

Equation 199

⁴⁰⁷ 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see “New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs” October 2010, page 99. Data collection discussed in Appendix D of the EM&V team’s Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

⁴⁰⁸ Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database. <https://www.ahridirectory.org/>.

Where:

$T_{\text{SupplySeasonal}}$ = Seasonal supply water temperature (see Table 214)
 CF = Peak coincidence factor (see Table 215)

Table 214. Showerhead TSRVs—Water Mains Temperatures

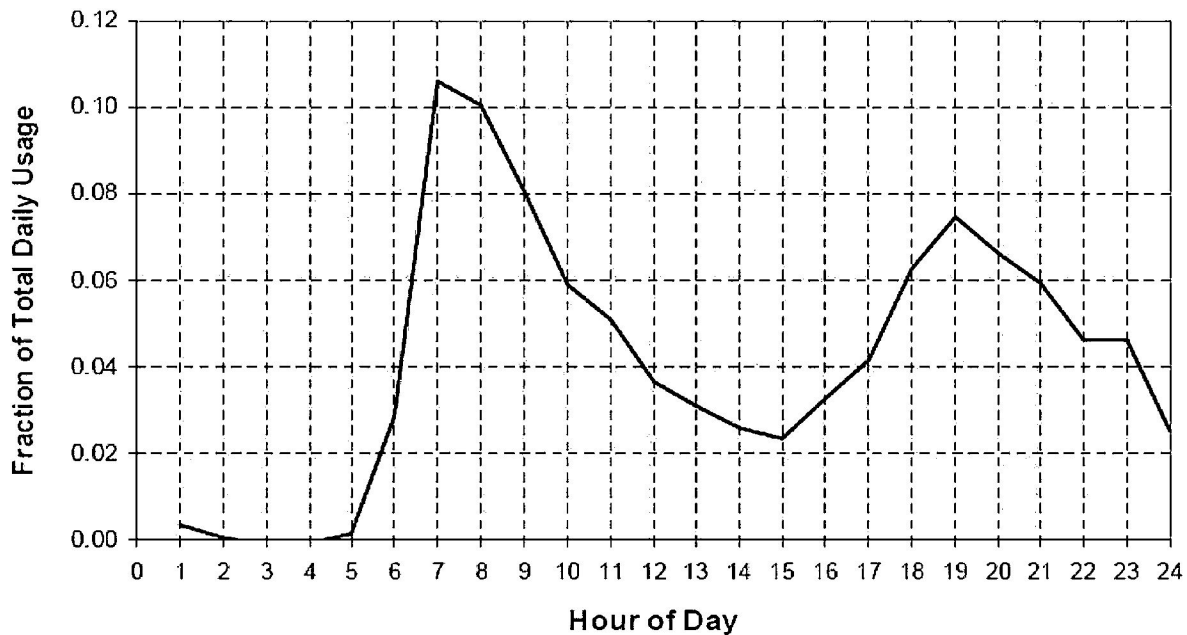
Climate zone	Water mains temperature (°F) ⁴⁰⁹		
	$T_{\text{SupplyAverage}}$	$T_{\text{SupplySeasonal}}$	
		Summer	Winter
Climate Zone 1: Amarillo	62.9	73.8	53.7
Climate Zone 2: Dallas	71.8	84.0	60.6
Climate Zone 3: Houston	74.7	84.5	65.5
Climate Zone 4: Corpus Christi	77.2	86.1	68.5
Climate Zone 5: El Paso	70.4	81.5	60.4

Table 215. Showerhead TSRVs—Peak Coincidence Factors

Climate zones	Summer	Winter
Climate Zone 1: Amarillo	0.039	0.073
Climate Zone 2: Dallas	0.035	0.075
Climate Zone 3: Houston	0.038	0.080
Climate Zone 4: Corpus Christi	0.038	0.068
Climate Zone 5: El Paso	0.028	0.069

⁴⁰⁹ Based on typical meteorological year (TMY) dataset for TMY3: <https://nsrdb.nrel.gov/about/tmy.html>.

Figure 5. Showerhead TSRVs—Shower, Bath, and Sink Hot Water Use Profile⁴¹⁰



Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Claimed Peak Demand Savings

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

⁴¹⁰ Building America Performance Analysis Procedures for Existing Homes.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-Shrhd.⁴¹¹ This value is consistent with the EUL reported for a low-flow showerhead in the 2014 California Database for Energy Efficiency Resources (DEER).⁴¹²

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Flow rate in gallons per minute (gpm) of showerhead installed
- Water heater type (heat pump, electric resistance)
- DHW recovery efficiency (RE) or COP, if available

Document Revision History

Table 216. Nonresidential Showerhead Temperature Sensitive Restrictor Valves Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.
v9.0	10/2021	TRM v9.0 update. Restricted measure to electricity savings and removed gas savings coefficients. Updated EUL reference.

⁴¹¹ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.

⁴¹² 2014 California Database for Energy Efficiency Resources. <http://www.deeresources.com/>.

2.6.3 Tub Spout and Showerhead Temperature-Sensitive Restrictor Valves Measure Overview

TRM Measure ID: NR-WH-TV

Market Sector: Commercial

Measure Category: Water Heating

Applicable Building Types: Lodging

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure consists of replacing existing tub spouts and showerheads with an automatically diverting tub spout and showerhead system with a temperature sensitive restrictor valve (TSRV)⁴¹³ between the existing shower arm and showerhead. The tub spout will contain temperature sensitive restrictor technology that will cause the tub spout to automatically engage the anti-leak diverter once the water reaches a set temperature (generally 95°F). The water will divert to a showerhead with a normally closed valve that will prevent the hot water from going down the drain prior to the user entering the shower, thereby eliminating behavioral waste and tub spout leakage waste.

Eligibility Criteria

These deemed savings are for tub spout and showerhead systems with temperature sensitive restrictor technology installed in new construction or as a retrofit measure in commercial lodging applications. Buildings must have electrically-fueled hot water to be eligible for this measure.

Baseline Condition

The baseline condition is the commercial lodging tub spout with a standard diverter and a standard (2.5 gpm) showerhead.

⁴¹³ A temperature-sensitive restrictor valve is any device that uses water temperature to regulate water flow in showers.

High-Efficiency Condition

The high-efficiency condition is an anti-leak, automatically diverting tub spout system with temperature sensitive restrictor technology installed on a commercial lodging shower arm and showerhead with a standard (2.5 gpm) or low-flow (2.0, 1.75, or 1.5 gpm) showerhead.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Estimated Hot Water Usage Reduction

This system provides savings in two parts: elimination of behavioral waste (hot water that goes down the drain prior to the user entering the shower) and elimination of tub spout diverter leakage.

Part 1: To determine baseline gallons of behavioral waste per year, the following formula was used:

$$\text{Annual Showerhead Behavioral Waste} = \%WUE_{SH} \times SHFR \times BW \times n_S \times 365 \frac{\text{days}}{\text{year}} \times \frac{OCC}{n_{SH}}$$

Equation 200

$$\text{Annual Tub Spout Behavioral Waste} = \%WUE_{TS} \times TSFR \times BW \times n_S \times 365 \frac{\text{days}}{\text{year}} \times \frac{OCC}{n_{SH}}$$

Equation 201

Where:

$\%WUE_{SH}$	=	Showerhead percentage of warm-up events (see Table 217)
$\%WUE_{TS}$	=	Tub spout percentage of warm-up events (see Table 217)
$SHFR$	=	Showerhead flow rate, gallons per minute (gpm) (see Table 217)
$TSFR$	=	Tub spout flow rate, gallons per minute (gpm) (see Table 217)
BW	=	Behavioral waste, minutes per shower (see Table 217)
n_S	=	Number of showers per occupied room per day (see Table 217)
365	=	Constant to convert days to years (see Table 217)
OCC	=	Occupancy rate (see Table 217)
n_{SH}	=	Number of showerheads per room (see Table 217)

Applying the formula to the values from Table 217 returns the following values:

$$\text{Showerhead (1.5 GPM): } 0.6 \times \left(1.5 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} \right) = 662$$

$$\text{Showerhead (1.75 GPM): } 0.6 \times \left(1.75 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} \right) = 772$$

$$\text{Showerhead (2.0 GPM): } 0.6 \times \left(2.0 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} \right) = 882$$

$$\text{Showerhead (2.5 GPM): } 0.6 \times \left(2.5 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} \right) = 1,103$$

$$\text{Tub Spout (5.0 GPM): } 0.4 \times \left(5.0 \times 1.742 \times 1.756 \times 365 \times \frac{0.659}{1.0} \right) = 1,471$$

Part 2: To determine baseline gallons of diverter leakage per year, the following formula was used:

$$\text{Annual Diverter Waste} = \text{DLR} \times t_s \times n_s \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{OCC}}{n_{SH}}$$

Equation 202

Where:

DLR = Diverter leakage rate (gpm) (see Table 217)

t_s = Shower time (min/shower) (see Table 217)

Applying the formula to the values used for Texas from Table 217 returns the following values:

$$\text{Diverter (0.8 GPM): } 0.8 \times 7.8 \times 1.756 \times 365 \times \frac{0.659}{1.0} = 2,634$$

Part 3: To determine gallons of water saved per year can be found by multiplying the total waste by the percentage of hot water from Table 217.

$$\text{Gallons of hot water saved} = (\text{SHBW} + \text{TSBW}) \times \text{HW}\%_{SH,TS} + \text{DW} \times \text{HW}\%_D$$

Equation 203

Where:

SHBW = Showerhead behavioral waste (gal)

TSBW = Tub-spout behavioral waste (gal)

DW = Diverter waste (gal)

$HW\%_{SH,TS}$ = Showerheads and tub-spout hot water percentage (see Table 217)

$HW\%_D$ = Diverter hot-water percentage (see Table 217)

Applying the formula to the values from Table 217 returns the following values:

Total Annual Waste (1.5 gpm): $(662 + 1,471) \times 0.825 + 2,634 \times 0.737 = 3,700$

Total Annual Waste (1.75 gpm): $(772 + 1,471) \times 0.825 + 2,634 \times 0.737 = 3,791$

Total Annual Waste (2.0 gpm): $(882 + 1,471) \times 0.825 + 2,634 \times 0.737 = 3,882$

Total Annual Waste (2.5 gpm): $(1,103 + 1,471) \times 0.825 + 2,634 \times 0.737 = 4,064$

Table 217. Tub Spout/Showerhead TSRVs—Hot Water Usage Reduction

Description	Part 1—Behavioral waste		Part 2—Diverter leakage	Part 3—Total
	Showerhead warm-up	Tub spout warm-up		
Baseline showerhead flow rate (gpm)	1.5, 1.75, 2.0, or 2.5			N/A
Tub-spout flow rate (gpm) ⁴¹⁴	N/A	5.0		N/A
Percentage of warm-up events ⁴¹⁵	60%	40%		N/A
Average behavioral waste (minutes per shower) ⁴¹⁶		1.742		N/A
Average diverter leakage-rate (gpm) ⁴¹⁷		N/A	0.80	N/A
Average shower time (minutes) ⁴¹⁸		N/A	7.8	N/A
Showers/occupied room/day ⁴¹⁹				1.756
Occupancy rate ⁴²⁰				65.9%
Showers/room ⁴²¹				1.0

⁴¹⁴ Assumption from (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.

⁴¹⁵ Percent of warm-up events from (Sherman 2014) Disaggregating Residential Shower Warm-Up Waste (Appendix B, Question 8).

⁴¹⁶ Shower Stream 2019 pilot study based on 747 metered shower events with an average duration of 104.51 seconds. This represents a subset of the total data set, as this value was not recorded for the entire data set. This assumption will be updated in future years to reflect additional pilot study data.

⁴¹⁷ Average diverter leak rate from (Taitem 2011) Taitem Tech Tip – Leaking Shower Diverters.

⁴¹⁸ Cadmus and Opinion Dynamics Evaluation Team, “Memorandum: Showerhead and Faucet Aerator Meter Study”. Prepared for Michigan Evaluation Working Group.

⁴¹⁹ Shower Stream 2019 pilot study based on 2,406 metered shower events. Weighted average calculated by dividing total shower events by total number of devices. This assumption will be updated in future years to reflect additional pilot study data.

⁴²⁰ 2001-2019 U.S. hotel occupancy rates from Statista. <https://www.statista.com/statistics/200161/us-annual-accomodation-and-lodging-occupancy-rate/>. Used average of last 5 years (2015-2019).

⁴²¹ Assuming industry standard for standard one-bathroom rooms.

Description	Part 1—Behavioral waste		Part 2—Diverter leakage	Part 3—Total
	Showerhead warm-up	Tub spout warm-up		
Gallons behavioral waste per tub spout/showerhead per year (1.5 gpm)	662	1,471	2,634	4,766
Gallons behavioral waste per tub spout/showerhead per year (1.75 gpm)	772			4,877
Gallons behavioral waste per tub spout/showerhead per year (2.0 gpm)	882			4,987
Gallons behavioral waste per tub spout/showerhead per year (2.5 gpm)	1,103			5,207
Percentage hot water ⁴²²	80-85%, or 82.5% average		73.7%	N/A
Gallons of hot water saved per year (1.5 gpm)			N/A	3,700
Gallons of hot water saved per year (1.75 gpm)			N/A	3,791
Gallons of hot water saved per year (2.0 gpm)			N/A	3,882
Gallons of hot water saved per year (2.5 gpm)			N/A	4,064

Energy Savings Algorithms

Energy savings for this measure are calculated as follows:

$$\text{Energy Savings per TS System} = \frac{\rho \times C_p \times V \times (T_{\text{SetPoint}} - T_{\text{SupplyAverage}})}{RE \times 3,412}$$

Equation 204

Where:

ρ	=	Water density, 8.33 lbs/gallon
C_p	=	Specific heat of water, 1 Btu/lb°F
V	=	Gallons of hot water saved per year per showerhead (see Table 217)
T_{SetPoint}	=	Water heater setpoint: 120°F ⁴²³

⁴²² Average percentage of hot water for warm-up events from (Lutz 2004) Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems and (Sherman 2015) Calculating Savings For: Auto-Diverting Tub Spout System with ShowerStart TSV.

⁴²³ 120°F represents the assumed water heater setpoint. New York Department of Public Service recommends using water heater setpoint as a default value, see “New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs” October 2010, page 99. Data collection discussed in Appendix D of the EM&V team’s Annual Statewide Portfolio Report for Program Year 2014-Volume 1, Project Number 40891 (August 2015), also supports a default value of 120°F.

- T_{Supply} = Average supply water temperature (see Table 218)
- RE = Recovery efficiency (or in the case of heat-pump water heaters, COP); if unknown, use 0.98 as a default for electric resistance water heaters, or 2.2 for heat-pump water heaters⁴²⁴
- 3,412 = Constant to convert from Btu to kWh

Demand Savings Algorithms

Demand savings are calculated by substituting the average supply temperature for the average seasonal temperature, multiplying by a coincidence factor equivalent to the daily fraction hot water use during the weighted peak hour for each climate zone (see Volume 1, Section 4), and dividing by 365 days/year.

$$\text{Demand Savings per TS System} = \frac{\rho \times C_p \times V \times (T_{SetPoint} - T_{SupplySeasonal})}{RE \times 3,412 \times 365} \times CF$$

Equation 205

Where:

- $T_{SupplySeasonal}$ = Seasonal-supply water temperature (see Table 218)
- CF = Peak coincidence factor (see Table 219)

Table 218. Tub Spout/Showerhead TSRVs—Water Mains Temperatures

Climate zone	Water mains temperature (°F) ⁴²⁵		
	$T_{SupplyAverage}$	$T_{SupplySeasonal}$	
		Summer	Winter
Zone 1: Amarillo	62.9	73.8	53.7
Zone 2: Dallas	71.8	84.0	60.6
Zone 3: Houston	74.7	84.5	65.5
Zone 4: Corpus Christi	77.2	86.1	68.5
Zone 5: El Paso	70.4	81.5	60.4

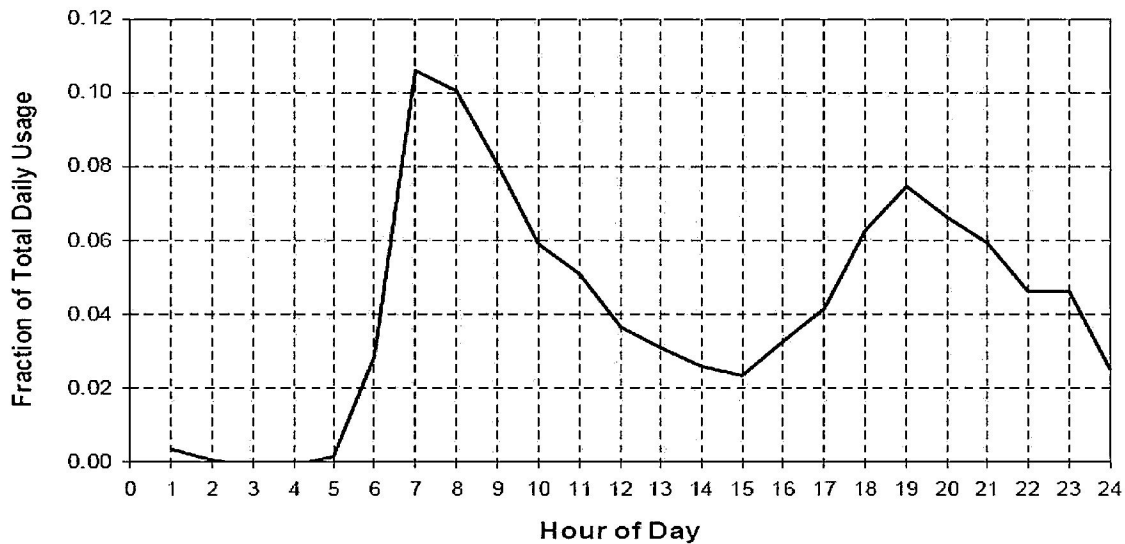
⁴²⁴ Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database. <https://www.ahridirectory.org/>.

⁴²⁵ Based on typical meteorological year (TMY) dataset for TMY3: <https://nsrdb.nrel.gov/about/tmy.html>.

Table 219. Tub Spout/Showerhead TSRVs—Peak Coincidence Factors

Climate zones	Summer	Winter
Zone 1: Amarillo	0.039	0.073
Zone 2: Dallas	0.035	0.075
Zone 3: Houston	0.038	0.080
Zone 4: Corpus Christi	0.038	0.068
Zone 5: El Paso	0.028	0.069

Figure 6. Tub Spout/Showerhead TSRVs—Shower, Bath, and Sink Hot Water Use Profile⁴²⁶



Deemed Energy and Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Claimed Peak Demand Savings

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

⁴²⁶ Building America Performance Analysis Procedures for Existing Homes.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID WtrHt-WH-Shrhd.⁴²⁷

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Flow rate in gallons per minute (GPM) of showerhead installed
- Water heater type (heat pump, electric resistance)
- DHW recovery efficiency (RE) or COP, if available

Document Revision History

Table 220. Nonresidential Tub Sprout and Showerhead Temperature Sensitive Restrictor Valves Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.
v9.0	10/2021	TRM v9.0 update. Restricted measure to electricity savings and removed gas savings coefficients. Updated EUL reference.

⁴²⁷ DEER READI (Remote Ex-Ante Database Interface). <http://www.deeresources.com/index.php/readi>.