2.2.11 Small Commercial Smart Thermostats Measure Overview

TRM Measure ID: NR-HV-ST

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 32 through Table 36

Fuels Affected: Electricity

Decision/Action Types: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Energy modeling, engineering algorithms and estimates

Measure Description

This section summarizes the deemed savings methodology for the installation of a smart thermostat in small commercial applications.

Eligibility Criteria

All commercial customers with refrigerated air conditioning are eligible to claim cooling savings for this measure. Customers must have electric central heating (either an electric resistance furnace or a heat pump) to claim heating savings.

The thermostat must control a single-zone direct expansion (DX) split or packaged air conditioner (AC) or heat pump (HP) limited to 10 tons (120,000 btu/hr) or lower.

Customers should be advised against using the emergency heat (EM HEAT) setting on heat pump thermostats. This setting is meant only for use in emergency situations when the heat pump is damaged or malfunctioning. Supplemental heating automatically kicks on below freezing conditions using the regular HEAT setting. Contractors installing a new heat pump thermostat with equipment install shall advise customer of correct thermostat usage.

No demand savings should be claimed if the customer is participating in a utility load management program offering.

Baseline Condition

The baseline condition for retrofit applications is a manual or programmable thermostat. The baseline condition for new construction applications is a programmable thermostat.[237]

[237] IECC 2015 C40.2.4.2.

High-Efficiency Condition

The high-efficiency condition is a single-zone HVAC system being controlled by a smart or connected thermostat. The ENERGY STAR® qualified product listing[238] does not include units marketed for commercial applications. Until those units are included, all products marketed as commercial smart or connected thermostats are allowed to use the savings methodology specified in this measure.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for energy and demand savings for small commercial smart thermostats.

$$kWh_{Savings} = kWh_{Cooling} + kWh_{Heating}$$

Equation 66

$$kWh_{Cooling} = CAP_C \times \frac{1\,kW}{1{,}000\,W} \times \frac{1}{\eta_C} \times EFLH_C \times CRF \times BAF$$

Equation 67

$$kWh_{Heating} = CAP_H \times \frac{1\,kW}{1{,}000\,W} \times \frac{1}{\eta_H} \times EFLH_C \times HRF \times BAF$$

Equation 68

$$kW_{Summer} = CAP_C \times \frac{1\,kW}{1{,}000\,W} \times \frac{1}{\eta_C} \times DF_C \times CRF \times BAF$$

Equation 69

$$kW_{Winter} = CAP_H \times \frac{1\,kW}{1{,}000\,W} \times \frac{1}{\eta_H} \times DF_H \times HRF \times BAF$$

Equation 70

Where:

$CAP_{C/H}$ = *Controlled-HVAC rated cooling/heating capacity (Btuh)*[239]

$\eta_{C/H}$ = *HVAC rated cooling/heating efficiency (see Table 32 for retrofit applications; use rated system efficiencies from AHRI or equivalent certification for new construction)*

Note: For heating equipment rated in COP, convert to HSPF by multiplying by 3.412. Heating efficiency should be converted from 1.0 COP and set to 3.412 HSPF when

[238] ENERGY STAR® QPL: https://www.energystar.gov/productfinder/product/certified-connected-thermostats/results.
[239] Eligible cooling and heating capacity is capped at 10 tons (or 120,000 btu/hr).

thermostat is installed in combination with centrally controlled electric resistance heat.[240]

$EFLH_{C/H}$ = *Cooling/heating equivalent full-load hours (see Table 35 through Table 39)*

$DF_{C/H}$ = *Cooling/heating demand factor (see Table 35 through Table 39)*

CRF = *Cooling reduction factor = 10%*[241]

HRF = *Heating reduction factor = 8%*[242]

BAF = *Baseline adjustment factor (1.0 for manual baseline, 0.6 for programmable and new construction baselines, and 0.8 for unknown baseline)*[243] [244]

Deemed Energy and Demand Savings Tables

Deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone in the Split and Packaged Air Conditioners and Heat Pumps measure in Table 35 through Table 39.

Claimed Peak Demand Savings

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

Claimed Peak Demand Savings

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 11 years as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID HV-ProgTstat.[245]

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[240] COP converted to HSPF using HSPF = COP ÷1,055 J/Btu x ,600 J/W-h = COP x 3.412.

[241] Lower 95 percent confidence limit of weighted national average assumed for Residential Connected Thermostats measure in Volume 2. While not directly applicable to commercial applications, this approach was used by the IL TRM as a precursor to sector specific data collection. Additionally, the deemed value falls between the range observed in other state TRMs (from 2-5% in the Mid-Atlantic TRM to 14-20% in the WI TRM). This factor is approved on a probationary basis with intent to review consumption data of sampling of participating projects after at least two years of measure availability.

[242] Ibid.

[243] This factor represents the ratio of thermostat adjustment savings to thermostat replacement savings. It is based on actual thermostat algorithm data (i.e., degrees of setback, hours values, fan models) from two years of ComEd AirCare Plus Program data (PY9+ and CY2018), including 382 thermostat adjustment installations and 3,847 thermostat replacement installations.

[244] Review of ComEd 2020 Baseline Study and 2019-2020 Program Data indicates that replacement thermostats are approximately 50% manual and 50% programmable. The unknown value may be applied as a default if applied consistently for all thermostats in a program year.

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

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Decision/action type: retrofit, new construction
- Baseline thermostat type (manual, programmable, unknown)
- Manufacturer
- Model number
- Quantity of newly installed thermostats
- Building type
- HVAC equipment age (retrofit only)
- Cooling type (split AC, packaged AC, split HP, packaged HP)
- Heating type (gas, electric resistance, HP)
- Cooling capacity (btuh)
- Heating capacity (btuh)
- Rated cooling efficiency (new construction only)
- Rated heating efficiency (new construction only)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 108. Nonresidential Small Commercial Smart Thermostats Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin.

2.3 NONRESIDENTIAL: BUILDING ENVELOPE

2.3.1 ENERGY STAR® Cool Roofs Measure Overview

TRM Measure ID: NR-BE-CR

Market Sector: Commercial

Measure Category: Building envelope

Applicable Building Types: All commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Energy modeling, engineering algorithms, and estimates

Measure Description

Reflective roofing materials reduce the overall heat load on a building by reducing the total heat energy absorbed into the building system from incident solar radiation. This reduction in total load provides space cooling energy savings during the cooling season but reduces free heat during the heating season, so the measure saves energy in the summer but uses more energy in winter. Cool roofs are most beneficial in warmer climates and may not be recommended for buildings where the primary heat source is electric resistance. The measure is for retrofit of existing buildings.

Eligibility Criteria

The ENERGY STAR® roofing products certification program was discontinued effective June 1, 2022.[246] Moving forward, installed roofing products will still be required to demonstrate compliance with the previous ENERGY STAR® specification.[247] ~~Measures installed through utility programs must be a roof that is compliant with the current ENERGY STAR® specification, effective July 2017.[248]~~ For nonresidential facilities, these criteria for a high-efficiency roof include:

[246] ENERGY STAR® Roof Products Sunset Decision Memo. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Roof%20Products%20Sunset%20Decision%20Memo.pdf.

[247] ENERGY STAR® Program Requirements for Roof Products v2.1. https://www.energystar.gov/ia/partners/product_specs/program_reqs/roofs_prog_req.pdf.

~~[248] ENERGY STAR® Roof Products Specification. https://www.energystar.gov/products/building_products/roof_products/key_product_criteria.~~

- An existing roof undergoing retrofit conditions as further defined under high-efficiency condition below; a roof installed in a new construction application is not eligible for applying these methodologies.
- A roof with a low-slope of 2:12 inches or less[249]
- An initial solar reflectance of greater than or equal to 65 percent
- A 3-year ~~Maintenance of~~ solar reflectance of greater than or equal to 50 percent ~~three years after installation under normal conditions~~
- 75 percent of the roof surface over conditioned space must be replaced
- No significant obstruction of direct sunlight to roof
- The facility must be conditioned with central cooling, heating, or both
- ~~In lieu of the former Be listed on the~~ ENERGY STAR® list of qualified products[250], roofing product must now ~~or~~ have a performance rating that is validated by the Cool Roof Rating Council (CRRC)[251,252] and be listed on the CRRC Rated Roof Products Directory.[253] This is consistent with the former ~~,~~ ENERGY STAR® test criteria's[254] allowances for products already participating in the CRRC Product Rating Program[255] to submit solar reflectance and thermal emittance product information derived from CRRC certification.
- ~~The ENERGY STAR® specification for roof products will sunset effective June 1, 2022.[256] No new roof products will be certified as of June 1, 2021. At this point, ENERGY STAR® legacy or CRRC product certification will be required to demonstrate compliance with the previous ENERGY STAR® specification.~~

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

Baseline Condition

The baseline is the thermal resistance (i.e., R-value) of the existing roof make-up and the solar reflectance and emissivity of the surface layer. The R-value is estimated based on code

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[249] As defined in proposed ASTN Standard E 1918-97.
[250] ~~ENERGY STAR® Certified Roofs. http://www.energystar.gov/productfinder/product/certified-roof-products/.~~
[251] CRRC guidance for roof rating alternative to discontinued ENERGY STAR® program. https://coolroofs.org/documents/CRRC-ENERGY-STAR-Sunset-Info-Sheet-2022-03-07.pdf.
[252] CRRC Roof Rating Program. https://coolroofs.org/programs/roof-rating-program.
[253] CRRC Rated Roof Products Directory. https://coolroofs.org/directory/roof.
[254] ~~ENERGY STAR® Program Requirements for Roof Products v2.1. https://www.energystar.gov/ia/partners/product_specs/program_reqs/roofs_prog_req.pdf.~~
[255] CRRC Rated Products Directory: https://coolroofs.org/directory.
[256] ~~ENERGY STAR® Roof Products Sunset Decision Memo. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Roof%20Products%20Sunset%20Decision%20Memo.pdf.~~

envelope requirements applicable in the year of construction. Solar reflectance and emissivity of the surface layer are assumed to be 0.2 and 0.9, respectively, based on roof properties listed in the LBLN Roofing Materials Database.[257]

The cooling and heating efficiencies are assumed based on the space conditioning of the top floor of the building and are based on typical code requirements applicable in the year of construction.

Table 109. Cool Roofs—Assumed Cooling and Heating Efficiencies (COP)

Year of construction; applicable code	RTU	PTHP cooling	PTHP heating	Air-cooled chiller	Water-cooled chiller
Before 2011; 2000 IECC	2.9	2.9	2.9	2.5	4.2
Between 2011-2016; 2009 IECC	3.8	3.1	2.9	2.8	5.5
After 2016; 2015 IECC	3.8	3.1	2.9	2.8	5.5

High-Efficiency Condition

The high-efficiency condition depends on the project scope. The project scope is defined as one of:

- Adding surface layer only
- Adding insulation and surface layer
- Rebuilding entire roof assembly

If the project scope is only to add a new ~~ENERGY STAR®~~ CRRC-rated material as the new surface layer, then the R-value used for the baseline condition is used for the high-efficiency condition. If the project scope is to add insulation and a~~n~~ ~~ENERGY STAR®~~ CRRC-~~R~~rated material as the new surface layer, then the R-value of the additional insulation is added to the R-value used for the baseline condition. If the entire roof assembly is rebuilt, then the R-value for each layer of the new roof construction is summed to get a total new R-value.

The measure requires installation of roof products that have been rated by the CRRC and demonstrate compliance with the previous ENERGY STAR® certified roof product performance specifications for the relevant roof application. Initial and 3-year reflectance ratings must meet or exceed the minimum thresholds specified in Table 110.

[257] Lawrence Berkeley National Lab Cool Roofing Material Database. https://heatisland.lbl.gov/resources/cool-roofing-materials-database.

Table 110. Cool Roofs—ENERGY STAR® Specification[258]

Roof slope	Characteristic	Performance specification
Low slope ≤ 2/12	Initial solar reflectance	≥ 0.65
	3-year solar reflectance	≥ 0.50

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy savings are estimated using EnergyPlus v8.3.0 whole-building simulation. The prototype building characteristics match those used for developing commercial HVAC demand factors and EFLH and can be found from Table 112 through Table 116. The savings represent the difference of the modeled energy use of the baseline condition and the high-efficiency condition divided by the square foot of the roof area. The demand savings are calculated following the method described in TRM Volume 1.

The deemed energy and demand savings factors are used in the following formulas to calculate savings:

$$Energy\ Savings = Roof\ Area \times ESF$$

Equation 71

$$Peak\ Summer\ Demand\ Savings = Roof\ Area \times PSDF \times 10^{-5}$$

Equation 72

$$Peak\ Winter\ Demand\ Savings = Roof\ Area \times PWDF \times 10^{-6}$$

Equation 73

Where:

Roof Area	=	*Total area of ENERGY STAR® roof in square feet*
ESF	=	*Energy Savings Factor from Table 112 through Table 116 by building type, pre/post insulation levels, and heating/cooling system*
PSDF	=	*Peak Summer Demand Factor from Table 112 through Table 116 by building type, pre/post insulation levels, and heating/cooling system*
PWDF	=	*Peak Winter Demand Savings Factor from Table 112 through Table 116 by building type, pre/post insulation levels, and heating/cooling system*

[258] ENERGY STAR® Roof Products Specification. https://www.energystar.gov/products/building_products/roof_products/key_product_criteria.

If the insulation levels are unknown, use the mapping in Table 111 to estimate the R-value based on the year of construction.

Table 111. Cool Roofs—Estimated R-Value based on Year of Construction

Year of construction	Estimated R-value[259]
Before 2011	R ≤ 13
Between 2011 - 2016	13 < R ≤ 20
After 2016	20 < R

Table 112. Cool Roofs—Savings Factors for Amarillo (Climate Zone 1)

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.72	19.28	31.74
	R ≤ 13	13 < R ≤ 20	1.26	36.23	36.71
	R ≤ 13	20 < R	1.25	38.58	35.31
	13 < R ≤ 20	13 < R ≤ 20	0.13	4.81	1.88
	13 < R ≤ 20	20 < R	0.12	6.47	0.48
	20 < R	20 < R	0.09	3.32	1.30
Education - chiller	R ≤ 13	R ≤ 13	0.65	11.80	8.31
	R ≤ 13	13 < R ≤ 20	1.10	21.76	31.52
	R ≤ 13	20 < R	1.25	25.53	37.31
	13 < R ≤ 20	13 < R ≤ 20	0.26	4.85	4.59
	13 < R ≤ 20	20 < R	0.38	7.80	9.20
	20 < R	20 < R	0.17	3.40	1.17
Education - RTU	R ≤ 13	R ≤ 13	0.26	8.26	2.62
	R ≤ 13	13 < R ≤ 20	0.43	15.47	12.49
	R ≤ 13	20 < R	0.49	18.20	14.02
	13 < R ≤ 20	13 < R ≤ 20	0.12	4.11	2.05
	13 < R ≤ 20	20 < R	0.18	6.67	3.58
	20 < R	20 < R	0.08	2.91	0.28
Office - chiller	R ≤ 13	R ≤ 13	0.21	6.80	1.43
	R ≤ 13	13 < R ≤ 20	0.31	3.44	3.50
	R ≤ 13	20 < R	0.33	19.30	3.87
	13 < R ≤ 20	13 < R ≤ 20	0.09	16.58	0.11
	13 < R ≤ 20	20 < R	0.11	5.94	0.47
	20 < R	20 < R	0.06	2.36	0.08

[259] Estimates R-values are based on applicable code requirements in the year of construction.

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Office - RTU	R ≤ 13	R ≤ 13	0.28	7.46	11.88
	R ≤ 13	13 < R ≤ 20	0.87	15.48	168.51
	R ≤ 13	20 < R	1.10	18.61	236.76
	13 < R ≤ 20	13 < R ≤ 20	0.15	4.12	-1.23
	13 < R ≤ 20	20 < R	0.38	6.73	67.02
	20 < R	20 < R	0.11	2.92	-2.61
Hotel	R ≤ 13	R ≤ 13	0.07	1.33	-2.60
	R ≤ 13	13 < R ≤ 20	0.07	1.83	6.98
	R ≤ 13	20 < R	0.07	2.03	11.77
	13 < R ≤ 20	13 < R ≤ 20	0.04	0.81	-1.45
	13 < R ≤ 20	20 < R	0.04	1.00	3.39
	20 < R	20 < R	0.03	0.60	-1.12
Warehouse	R ≤ 13	R ≤ 13	0.04	3.83	-0.20
	R ≤ 13	13 < R ≤ 20	0.11	6.99	3.89
	R ≤ 13	20 < R	0.14	8.07	5.35
	13 < R ≤ 20	13 < R ≤ 20	0.01	1.35	-0.10
	13 < R ≤ 20	20 < R	0.04	2.24	1.36
	20 < R	20 < R	0.01	0.90	-0.07
Other	R ≤ 13	R ≤ 13	0.04	1.33	-2.60
	R ≤ 13	13 < R ≤ 20	0.07	1.83	3.50
	R ≤ 13	20 < R	0.07	2.03	3.87
	13 < R ≤ 20	13 < R ≤ 20	0.01	0.81	-1.45
	13 < R ≤ 20	20 < R	0.04	1.00	0.47
	20 < R	20 < R	0.01	0.60	-2.61

Table 113. Cool Roofs—Savings Factors for Dallas (Climate Zone 2)

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.61	22.03	13.53
	R ≤ 13	13 < R ≤ 20	0.97	37.67	17.30
	R ≤ 13	20 < R	0.98	40.54	17.32
	13 < R ≤ 20	13 < R ≤ 20	0.16	7.57	1.28
	13 < R ≤ 20	20 < R	0.17	9.67	1.29
	20 < R	20 < R	0.13	6.22	1.04

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Education - chiller	R ≤ 13	R ≤ 13	0.56	10.49	5.11
	R ≤ 13	13 < R ≤ 20	0.82	16.50	8.60
	R ≤ 13	20 < R	0.92	18.86	11.17
	13 < R ≤ 20	13 < R ≤ 20	0.29	5.41	2.36
	13 < R ≤ 20	20 < R	0.36	7.28	4.55
	20 < R	20 < R	0.24	4.37	1.88
Education - RTU	R ≤ 13	R ≤ 13	0.27	10.65	1.53
	R ≤ 13	13 < R ≤ 20	0.39	18.31	3.68
	R ≤ 13	20 < R	0.43	21.33	4.89
	13 < R ≤ 20	13 < R ≤ 20	0.17	7.21	0.77
	13 < R ≤ 20	20 < R	0.21	10.08	1.97
	20 < R	20 < R	0.13	5.88	0.60
Office - chiller	R ≤ 13	R ≤ 13	0.23	11.99	0.81
	R ≤ 13	13 < R ≤ 20	0.33	27.48	1.78
	R ≤ 13	20 < R	0.34	30.55	1.93
	13 < R ≤ 20	13 < R ≤ 20	0.13	6.68	0.10
	13 < R ≤ 20	20 < R	0.15	9.76	0.26
	20 < R	20 < R	0.10	6.01	0.08
Office - RTU	R ≤ 13	R ≤ 13	0.27	12.14	14.86
	R ≤ 13	13 < R ≤ 20	0.52	24.53	84.63
	R ≤ 13	20 < R	0.62	29.45	112.16
	13 < R ≤ 20	13 < R ≤ 20	0.18	7.25	11.53
	13 < R ≤ 20	20 < R	0.28	11.09	39.06
	20 < R	20 < R	0.15	6.03	8.66
Hotel	R ≤ 13	R ≤ 13	0.07	1.71	-0.64
	R ≤ 13	13 < R ≤ 20	0.07	2.30	0.78
	R ≤ 13	20 < R	0.07	2.56	1.39
	13 < R ≤ 20	13 < R ≤ 20	0.05	1.17	-0.46
	13 < R ≤ 20	20 < R	0.05	1.42	0.17
	20 < R	20 < R	0.05	1.01	-0.36
Warehouse	R ≤ 13	R ≤ 13	0.05	4.01	-0.07
	R ≤ 13	13 < R ≤ 20	0.09	6.54	1.47
	R ≤ 13	20 < R	0.16	11.16	2.38
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.18	-0.05
	13 < R ≤ 20	20 < R	0.08	4.94	0.86
	20 < R	20 < R	0.01	1.02	-0.03

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Other	R ≤ 13	R ≤ 13	0.05	1.71	-0.64
	R ≤ 13	13 < R ≤ 20	0.07	2.30	0.78
	R ≤ 13	20 < R	0.07	2.56	1.39
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.17	-0.46
	13 < R ≤ 20	20 < R	0.05	1.42	0.17
	20 < R	20 < R	0.01	1.01	-0.36

Table 114. Cool Roofs—Savings Factors for Houston (Climate Zone 3)

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.62	17.21	9.86
	R ≤ 13	13 < R ≤ 20	1.00	29.60	17.11
	R ≤ 13	20 < R	1.01	31.61	16.52
	13 < R ≤ 20	13 < R ≤ 20	0.41	10.43	7.67
	13 < R ≤ 20	20 < R	0.41	11.89	7.07
	20 < R	20 < R	0.14	4.66	1.07
Education - chiller	R ≤ 13	R ≤ 13	0.62	9.56	-0.28
	R ≤ 13	13 < R ≤ 20	0.87	15.28	3.52
	R ≤ 13	20 < R	0.95	17.53	4.52
	13 < R ≤ 20	13 < R ≤ 20	0.33	5.04	-0.28
	13 < R ≤ 20	20 < R	0.39	6.81	0.50
	20 < R	20 < R	0.26	4.05	-0.29
Education - RTU	R ≤ 13	R ≤ 13	0.29	9.39	-0.03
	R ≤ 13	13 < R ≤ 20	0.40	15.76	0.90
	R ≤ 13	20 < R	0.44	18.26	1.08
	13 < R ≤ 20	13 < R ≤ 20	0.18	6.21	-0.01
	13 < R ≤ 20	20 < R	0.22	8.58	0.16
	20 < R	20 < R	0.14	5.08	-0.07
Office - chiller	R ≤ 13	R ≤ 13	0.25	9.45	0.70
	R ≤ 13	13 < R ≤ 20	0.33	21.39	1.26
	R ≤ 13	20 < R	0.34	23.54	1.23
	13 < R ≤ 20	13 < R ≤ 20	0.17	10.75	0.65
	13 < R ≤ 20	20 < R	0.18	12.84	0.61
	20 < R	20 < R	0.12	4.54	0.12

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Office - RTU	R ≤ 13	R ≤ 13	0.28	8.30	6.91
	R ≤ 13	13 < R ≤ 20	0.46	18.66	37.60
	R ≤ 13	20 < R	0.54	22.36	50.18
	13 < R ≤ 20	13 < R ≤ 20	0.19	5.42	4.29
	13 < R ≤ 20	20 < R	0.26	8.39	16.87
	20 < R	20 < R	0.15	4.35	3.35
Hotel	R ≤ 13	R ≤ 13	0.08	1.69	0.54
	R ≤ 13	13 < R ≤ 20	0.07	2.26	0.17
	R ≤ 13	20 < R	0.07	2.50	-0.02
	13 < R ≤ 20	13 < R ≤ 20	0.06	1.21	0.37
	13 < R ≤ 20	20 < R	0.05	1.43	0.21
	20 < R	20 < R	0.05	1.03	0.32
Warehouse	R ≤ 13	R ≤ 13	0.05	2.96	-0.09
	R ≤ 13	13 < R ≤ 20	0.09	5.13	0.76
	R ≤ 13	20 < R	0.16	9.21	1.26
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.32	-0.07
	13 < R ≤ 20	20 < R	0.08	4.66	0.43
	20 < R	20 < R	0.01	0.79	0.08
Other	R ≤ 13	R ≤ 13	0.05	1.69	-0.28
	R ≤ 13	13 < R ≤ 20	0.07	2.26	0.17
	R ≤ 13	20 < R	0.07	2.50	-0.02
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.21	-0.28
	13 < R ≤ 20	20 < R	0.05	1.43	0.16
	20 < R	20 < R	0.01	0.79	-0.29

Table 115. Cool Roofs—Savings Factors for Corpus Christi (Climate Zone 4)

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.62	13.05	54.33
	R ≤ 13	13 < R ≤ 20	0.99	21.99	35.94
	R ≤ 13	20 < R	1.00	23.21	34.63
	13 < R ≤ 20	13 < R ≤ 20	0.41	8.08	16.20
	13 < R ≤ 20	20 < R	0.41	8.95	14.89
	20 < R	20 < R	0.13	3.42	2.05

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Education - chiller	R ≤ 13	R ≤ 13	0.60	8.46	0.28
	R ≤ 13	13 < R ≤ 20	0.83	13.55	17.33
	R ≤ 13	20 < R	0.90	15.49	30.14
	13 < R ≤ 20	13 < R ≤ 20	0.31	4.48	-3.69
	13 < R ≤ 20	20 < R	0.36	6.00	6.37
	20 < R	20 < R	0.24	3.64	-0.06
Education - RTU	R ≤ 13	R ≤ 13	0.28	7.34	-0.41
	R ≤ 13	13 < R ≤ 20	0.38	11.78	5.15
	R ≤ 13	20 < R	0.41	13.53	8.09
	13 < R ≤ 20	13 < R ≤ 20	0.17	4.64	-1.46
	13 < R ≤ 20	20 < R	0.20	6.29	1.47
	20 < R	20 < R	0.14	3.77	-0.14
Office - chiller	R ≤ 13	R ≤ 13	0.22	6.44	2.33
	R ≤ 13	13 < R ≤ 20	0.31	13.55	2.86
	R ≤ 13	20 < R	0.32	15.30	2.47
	13 < R ≤ 20	13 < R ≤ 20	0.17	6.34	1.78
	13 < R ≤ 20	20 < R	0.18	7.96	1.40
	20 < R	20 < R	0.10	3.27	0.45
Office - RTU	R ≤ 13	R ≤ 13	0.26	5.02	23.11
	R ≤ 13	13 < R ≤ 20	0.40	8.66	78.05
	R ≤ 13	20 < R	0.45	10.09	100.16
	13 < R ≤ 20	13 < R ≤ 20	0.18	3.61	15.10
	13 < R ≤ 20	20 < R	0.24	4.83	37.21
	20 < R	20 < R	0.15	2.95	10.35
Hotel	R ≤ 13	R ≤ 13	0.07	1.13	1.99
	R ≤ 13	13 < R ≤ 20	0.07	1.44	-1.23
	R ≤ 13	20 < R	0.07	1.57	-2.70
	13 < R ≤ 20	13 < R ≤ 20	0.05	0.78	1.36
	13 < R ≤ 20	20 < R	0.05	0.90	0.00
	20 < R	20 < R	0.04	0.67	1.19
Warehouse	R ≤ 13	R ≤ 13	0.05	2.10	0.22
	R ≤ 13	13 < R ≤ 20	0.09	3.51	1.39
	R ≤ 13	20 < R	0.16	6.54	1.35
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.21	0.28
	13 < R ≤ 20	20 < R	0.08	3.71	0.24
	20 < R	20 < R	0.01	0.70	-0.07

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Other	R ≤ 13	R ≤ 13	0.05	1.13	-0.41
	R ≤ 13	13 < R ≤ 20	0.07	1.44	-1.23
	R ≤ 13	20 < R	0.07	1.57	-2.70
	13 < R ≤ 20	13 < R ≤ 20	0.02	0.78	-3.69
	13 < R ≤ 20	20 < R	0.05	0.90	0.00
	20 < R	20 < R	0.01	0.67	-0.14

Table 116. Cool Roofs—Savings Factors for El Paso (Climate Zone 5)

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.67	16.55	42.72
	R ≤ 13	13 < R ≤ 20	1.01	26.85	67.80
	R ≤ 13	20 < R	1.02	28.78	65.27
	13 < R ≤ 20	13 < R ≤ 20	0.19	5.83	6.64
	13 < R ≤ 20	20 < R	0.19	7.24	4.12
	20 < R	20 < R	0.15	4.74	5.40
Education - chiller	R ≤ 13	R ≤ 13	0.69	9.09	3.85
	R ≤ 13	13 < R ≤ 20	0.97	14.42	4.87
	R ≤ 13	20 < R	1.07	16.52	5.43
	13 < R ≤ 20	13 < R ≤ 20	0.36	4.80	1.87
	13 < R ≤ 20	20 < R	0.44	6.47	2.34
	20 < R	20 < R	0.28	3.91	1.19
Education - RTU	R ≤ 13	R ≤ 13	0.30	8.21	3.09
	R ≤ 13	13 < R ≤ 20	0.42	13.43	4.02
	R ≤ 13	20 < R	0.46	15.49	4.27
	13 < R ≤ 20	13 < R ≤ 20	0.18	5.16	1.47
	13 < R ≤ 20	20 < R	0.22	7.09	1.72
	20 < R	20 < R	0.14	4.14	0.86
Office - chiller	R ≤ 13	R ≤ 13	0.29	9.72	7.27
	R ≤ 13	13 < R ≤ 20	0.39	17.57	12.46
	R ≤ 13	20 < R	0.42	20.35	13.25
	13 < R ≤ 20	13 < R ≤ 20	0.17	6.68	0.12
	13 < R ≤ 20	20 < R	0.20	9.22	0.79
	20 < R	20 < R	0.14	5.39	2.02

Building type	Pre-R-value	Post R-value	ESF	PSDF	PWDF
Office - RTU	R ≤ 13	R ≤ 13	0.31	9.93	24.02
	R ≤ 13	13 < R ≤ 20	0.55	16.57	105.15
	R ≤ 13	20 < R	0.64	19.26	135.96
	13 < R ≤ 20	13 < R ≤ 20	0.20	5.75	16.21
	13 < R ≤ 20	20 < R	0.29	7.78	47.02
	20 < R	20 < R	0.16	4.70	12.77
Hotel	R ≤ 13	R ≤ 13	0.10	1.33	7.04
	R ≤ 13	13 < R ≤ 20	0.08	1.58	1.80
	R ≤ 13	20 < R	0.08	1.68	-0.78
	13 < R ≤ 20	13 < R ≤ 20	0.07	0.95	4.98
	13 < R ≤ 20	20 < R	0.06	1.04	2.57
	20 < R	20 < R	0.06	0.81	4.27
Warehouse	R ≤ 13	R ≤ 13	0.04	2.76	-0.61
	R ≤ 13	13 < R ≤ 20	0.09	4.91	1.33
	R ≤ 13	20 < R	0.15	8.27	2.06
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.31	-0.42
	13 < R ≤ 20	20 < R	0.07	3.98	0.30
	20 < R	20 < R	0.01	0.76	-0.19
Other	R ≤ 13	R ≤ 13	0.04	1.33	-0.61
	R ≤ 13	13 < R ≤ 20	0.08	1.58	1.33
	R ≤ 13	20 < R	0.08	1.68	-0.78
	13 < R ≤ 20	13 < R ≤ 20	0.02	0.95	-0.42
	13 < R ≤ 20	20 < R	0.06	1.04	0.30
	20 < R	20 < R	0.01	0.76	-0.19

Deemed Energy and Demand Savings Tables

There are no deemed energy or demand savings tables for this measure. Please use algorithms and inputs, as described above.

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 15 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID BldgEnv-CoolRoof.[260]

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

Program Tracking Data and Evaluation Requirements

The below list 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 or county location
- Building type
- Total and treated roofing square footage (over conditioned space)
- Roof slope
- Existing roof insulation R-value, or year of building construction
- New roof insulation R-value, if adding insulation
- New roofing initial solar reflectance
- New roofing 3-year solar reflectance
- New roofing rated life
- Copy of ~~ENERGY STAR®~~ CRRC certification ~~or alternative~~
- Copy of proof of purchase including date of purchase, manufacturer, and model
- Building type

~~Building Type~~ References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for Commercial Cool Roof.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~ENERGY STAR® Certified Cool Roof Products. http://www.energystar.gov/productfinder/product/certified-roof-products/.~~
- ~~IECC 2000 Table 802.2(17), 2009 Table 502.2(1), and 2015 Table C402.1.4~~

Document Revision History

Table 117. Nonresidential ENERGY STAR® Roofs 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. Clarified that reflectance is three years basis. Rounded off values, too many insignificant digits.

TRM version	Date	Description of change
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. Clarified eligibility criteria, baseline condition, and high-efficiency condition. Added R-values for more materials. Added new high-performance roof calculator for use in determining ENERGY STAR® roof savings.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. Changed savings methodology from algorithms to simulation models. Deemed savings are presented per square foot by building type and climate zone.
v7.0	10/2019	TRM v7.0 update. Minor error updates to Savings Factor Table for greater than and less than symbols. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. Added building type to tracking data requirements. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Changed eligibility criteria from strictly ENERGY STAR® to CRRC certification.

2.3.2 Window Treatments Measure Overview

TRM Measure ID: NR-BE-WT

Market Sector: Commercial

Measure Category: Building Envelope

Applicable Building Types: All commercial building types

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

Eligibility Criteria

This measure is applicable for treatment of single or double-paned clear glass windows without reflective or low-E coatings in south or west facing orientations (as specified in Table 118). Existing windows must have no solar films/screens, interior shades, or exterior awnings or overhangs, and must be installed in buildings that are mechanically cooled (DX or chilled water).

This methodology may be adapted for windows with existing shading devices on an individual project basis with prior evaluator approval of baseline solar heat gain coefficient (SHGC).

Baseline Condition

The baseline condition is single-pane clear glass, without existing window treatments.

High-Efficiency Condition

The high-efficiency condition is an eligible window treatment applied to eligible windows.

Energy and Demand Savings Methodology

The demand and energy savings equations in this section originated in calculations by the EUMMOT utilities, as presented in the EUMMOT program manual *Commercial Standard Offer Program: Measurement and Verification Guidelines for Retrofit and New Construction Projects.* The method estimates the reduction in solar heat gain/insolation attributable to a given window treatment using shading coefficients for the treated and untreated window and solar heat gain estimates by window orientation, according to ASHRAE Fundamentals. The reduction in building energy use attributable to the reduction in cooling system energy use is estimated based on the reduced heat removal requirement for a standard efficiency cooling system.

Savings Algorithms and Input Variables

$$Demand\ Savings_o\ [kW] = \frac{A_{film,o} \times SHGF_o \times \left(SHGC_{pre,o} - SHGC_{post,o}\right)}{3{,}412 \times COP}$$

Equation 74

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

Equation 75

$$Energy\ Savings_o\ [kWh] = \frac{A_{film,o} \times SHG_o \times \left(SHGC_{pre,o} - SHGC_{post,o}\right)}{3{,}412 \times COP}$$

Equation 76

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

Equation 77

Where:

Demand Savings	=	*Peak demand savings per window orientation*
Energy Savings	=	*Energy savings per window orientation*
$A_{film,o}$	=	*Area of window film applied to orientation [ft^2]*
$SHGF_o$	=	*Peak solar heat gain factor for orientation of interest [Btu/hr-ft^2-year]; see Table 118*
SHG_o	=	*Solar heat gain for orientation of interest [Btu/ft2-year]; see Table 118*
$SHGC_{pre}$	=	*Solar heat gain coefficient for existing glass with no interior-shading device; see Table 119*

$SHGC_{post}$	=	*Solar heat gain coefficient for new film/interior-shading device, from manufacturer specs*

Note: Shading coefficients (SC) have been retired, but if a product specification lists SC instead of SHGC, you can convert to SHGC by multiplying SC by 0.87.[261]

COP	=	*Cooling equipment COP based on Table 120 or actual COP equipment, whichever is greater; if building construction year is unknown, assume IECC 2009 as applicable code*
3,412	=	*Conversion factor [Btu/kWh]*

Table 118. Windows Treatments—Solar Heat Gain Factors[262]

Orientation	Solar heat gain (SHG) (Btu/ft²-year)	Peak hour solar heat gain (SHGF) (Btu/hr-ft²-year)				
		Zone 1[263]	Zone 2	Zone 3	Zone 4	Zone 5
South-East	158,844	28	30	26	27	35
South-South-East	134,794	28	31	28	28	37
South	120,839	37	44	47	45	56
South-South-West	134,794	88	94	113	113	101
South-West	158,844	152	151	170	173	141
West-South-West	169,696	191	184	201	206	160
West	163,006	202	189	201	207	155
West-North-West	139,615	183	167	171	178	128
North-West	107,161	136	120	115	121	85

Table 119. Windows Treatment—Recommended Clear Glass $SHGC_{pre}$ by Window Thickness[264]

Existing window thickness (inches)	$SHGC_{pre}$
Single-pane 1/8-inch clear glass	0.86
Single-pane 1/4-inch clear glass	0.81
Double-pane 1/8-inch clear glass	0.76
Double-pane 1/4-inch clear glass	0.70

[261] 2001 ASHRAE Handbook: Fundamentals, p. 30–39.

[262] Values are taken from the 1997 ASHRAE Fundamentals, Chapter 29 Table 17, based on the amount of solar radiation transmitted through single-pane clear glass for a cloudless day at 32°N Latitude for the 21st day of each month by hour of day and solar orientation. The SHG values listed above have been aggregated into daily totals for weekdays during the months of April through October.

[263] Coincidence factors specific to Climate Zone 1 could not be calculated since utility load data are not currently available for this region. In their absence, Climate Zone 2 values may be used.

[264] 2017 ASHRAE Handbook: Fundamentals, Chapter 15 Fenestration, Table 10 Solar Heat Gain Coefficient (SHGC).

Table 120. Recommended COP by HVAC System Type[265]

Year of construction; applicable code	AC/HP	PTAC/PTHP	Air-cooled chiller	Water-cooled chiller
Before 2011; 2000 IECC	2.9	2.9	2.5	4.2
Between 2011-2016; 2009 IECC	3.8	3.1	2.8	5.5
After 2016; 2015 IECC	3.8	3.1	2.8	5.5

Deemed Energy and Demand Savings Tables

There are no deemed energy or demand savings tables for this measure. Please use algorithms and inputs, as described above.

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID GlazDaylt-WinFilm.[266]

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:

- Existing window type, thickness, and SHGC
- Description of existing window presence of exterior shading from other buildings or obstacles
- Window film or solar screen SHGC
- Eligible window treatment application area by orientation (e.g., S, SSW, SW)
- Year of construction, if available
- Cooling equipment type
- Cooling equipment rated efficiency

[265] Based on review applicable codes, including IECC 2000, 2009, and 2015.
[266] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for reflective window films and sunscreens.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~1997 ASHRAE Fundamentals, Chapter 29, Table 17.~~
- ~~International Energy Conservation Code (IECC) 2000, 2009, and 2015~~

Document Revision History

Table 121. Nonresidential Window Treatments 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. Eliminated east-facing windows from consideration for energy savings.
v3.0	04/10/2015	TRM v3.0 update. References to EPE-specific deemed savings removed (EPE to adopt methods used by the other utilities). Demand savings: Frontier Energy updated to incorporate new peak demand definition. Provided deemed values for shading coefficients and HVAC efficiencies. SHGF: Used CZ2 savings for CZ1 until better values can be developed.
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 peak demand values for climate zones and PDPF values.
v9.0	10/2021	TRM v9.0 update. Corrected footnote for SC to SHGC conversion. Updated performance factors to 2017 ASHRAE Fundamentals. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. No revisions.

2.3.3 Entrance and Exit Door Air Infiltration Measure Overview

TRM Measure ID: NR-BE-DI

Market Sector: Commercial

Measure Category: Building Envelope

Applicable Building Types: All commercial building types

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 measure applies to the installation of weather stripping or door sweeps on entrance and exit doors for a contained, pressurized space. Entrance and exit doors often leave clearance gaps to allow for proper operation. The gaps around the doors allow for the infiltration of unconditioned air into the building, adding to the cooling and heating load of the HVAC system. Weatherstripping and door sweeps are designed to be installed along the bottom and jambs of exterior doors to prevent air infiltration to conditioned space.

Eligibility Criteria

Weatherstripping or doors sweeps must be installed on doors of a conditioned and/or heated space. Treated doors must have visible gaps of at least 1/8–3/4 inches along the outside edge of the door. Spaces with interior vestibule doors are not eligible.

Baseline Condition

The baseline standard for this measure is a commercial building with exterior doors that are not sealed from unconditioned space.

High-Efficiency Condition

The high-efficiency condition for this measure is a commercial building with exterior doors that have been sealed from unconditioned space using weather stripping and/or brush style door sweeps.

Energy and Demand Savings Methodology

This savings methodology was derived by analyzing TMY3 weather data for each Texas weather zone representative city.

Derivation of Pre-Retrofit Air Infiltration Rate

The pre-retrofit air infiltration rate for each crack width is calculated by applying the methodologies presented in Chapter 5 of the ASHRAE Cooling and Heating Load Calculation Manual (CHLCM).[267] Building type characteristics for a typical commercial building were found in the DOE study PNNL-20026,[268] and an average building height of 20 feet is assumed for the deemed savings approach.

Because air infiltration is a function of differential pressure due to stack effect, wind speed, velocity head, and the design conditions of the building, TMY3 for each Texas weather zone reference city was applied to account for the varying weather conditions that are characteristic throughout an average year.

Figure 5.13 from the ASHRAE CHLCM provides the infiltration rate based on various crack width and the corresponding pressure difference across a door. Figures 5.1 and 5.2 (CHLCM) provide the differential pressure due to stack and wind pressure necessary to determine the total pressure difference across the door.

Applying a regression analysis to Figure 5.1 returns an equation that allows solving for the pressure difference due to stack effect, Δp_s. The aggregate curve fit for Figure 5.1 is shown below where x is based on the dry bulb temperature from the TMY3 data, and the design temperature based on the appropriate seasonal condition.

$$\Delta p_s / C_d = 0.0000334003x - 0.00014468$$

Equation 78

Where C_d is an assumed constant, 0.63, and the neutral pressure distance is 10 feet.

From Figure 5.2, $\Delta p_w / C_p$ is determined by applying a polynomial regression, which returns an equation for solving for the pressure difference due to wind, Δp_w. The curve fit for Figure 5.2 is shown below where x is the wind velocity based on TMY3 data.

$$\Delta p_w / C_p = 0.00047749x^2 - 0.00013041x$$

Equation 79

Where C_p is an assumed constant, 0.13 (average wind pressure coefficient from Table 5.5 from CHLCM).

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[267] ASHRAE Cooling and Heating Load Calculation Manual, p. 5.8. 1980. http://portal.hud.gov/hudportal/documents/huddoc?id=doc_10603.pdf.

[268] Cho, H., K. Gowri, and B. Liu, "Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings." November 2010. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20026.pdf.

This yields the total pressure difference across the door, Δp_{Total}:

$$\Delta p_{Total} = \Delta p_s + \Delta p_w$$

Equation 80

Solving for Δp_{Total} allows for the air infiltration rate per linear foot to be determined in Figure 5.13 (CHLCM). Applying a power regression analysis for each crack width (described in inches) represented in Figure 5.13 (CHLCM) returns the equations listed below. In these equations, *Q* is the infiltration rate in cubic feet per minute through cracks around the door, and *P* is the perimeter of the door in feet.

$$Q/P_{1/8"} = 41.572x^{0.5120}$$

Equation 81

$$Q/P_{1/4"} = 81.913x^{0.5063}$$

Equation 82

$$Q/P_{1/2"} = 164.26x^{0.5086}$$

Equation 83

$$Q/P_{3/4"} = 246.58x^{0.5086}$$

Equation 84

These infiltration rates were further disaggregated based on TMY3 average monthly day and night conditions.

Derivation of Design and Average Outside Ambient Temperatures

Taking average daytime and nighttime outdoor temperature values, standard set points, and setbacks for daytime and nighttime design cooling and heating will yield the temperature difference needed for the sensible heat equation:

$$\Delta T = T_{design} - T_{avg\ outside\ ambient}$$

Equation 85

Where:

T_{design} = *Daytime and nighttime design temperature (°F, see Table 123)*

$T_{avg\ outside\ ambient}$ = *Average outside ambient temperature, specified by month (°F, see Table 122)*

Table 122. Average Monthly Ambient Temperatures (°F)[269]

	Climate zone 1 Amarillo		Climate zone 2 Dallas		Climate zone 3 Houston		Climate zone 4 Corpus Christi		Climate zone 5 El Paso	
Month	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Jan	41.5	31.5	48.1	40.3	54.8	47.0	58.1	50.9	50.9	42.4
Feb	44.9	34.5	52.8	44.8	59.4	50.5	61.7	54.4	55.8	45.2
Mar	52.9	40.7	63.6	54.4	65.5	56.8	69.1	61.3	61.0	48.2
April	65.4	52.7	71.4	62.7	73.1	64.7	75.9	67.7	72.7	60.5
May	69.2	57.2	77.6	68.7	79.4	71.1	80.5	72.0	80.9	69.0
June	79.9	69.7	85.3	75.0	85.1	76.2	86.4	77.9	88.2	76.1
July	84.5	72.1	90.4	80.6	87.8	78.0	88.6	78.0	86.7	76.5
Aug	81.4	69.7	89.1	79.2	88.0	77.5	88.0	78.4	84.2	74.4
Sept	75.3	64.3	84.5	73.8	85.5	73.6	85.0	75.2	80.9	67.3
Oct	63.6	50.4	70.2	59.9	75.4	61.8	77.5	67.9	70.2	59.7
Nov	48.5	38.5	59.3	52.3	67.6	57.9	72.3	63.8	57.3	47.0
Dec	41.8	32.4	49.5	41.8	59.2	50.0	60.4	53.7	49.1	39.4

Table 123. Daytime and Nighttime Design Temperatures

Temperature description	T_{design} (°F)
Daytime cooling design temperature	74
Daytime heating design temperature	72
Nighttime cooling design temperature[270]	78
Nighttime heating design temperature[271]	68

Savings Algorithms and Input Variables

To calculate HVAC load associated with air infiltration, the following sensible heat equation is used:

Electric Cooling Energy Savings

$$Cooling\ Energy\ Savings\ [kWh]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton} \times Hours_{day}}{12{,}000\ Btuh/ton}$$

Equation 86

[269] TMY3 climate data.
[270] Assuming 4-degree setback.
[271] Ibid.

$$Cooling\ Energy\ Savings\ [kWh]_{Night} = \frac{CFM_{pre,night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton} \times Hours_{night}}{12{,}000\ Btuh/ton}$$

Equation 87

$$Cooling\ Energy\ Savings\ [kWh] = Cooling\ Energy\ Savings\ [kWh]_{Day} + Cooling\ Energy\ Savings\ [kWh]_{Night}$$

Equation 88

Electric Heating Energy Savings

$$Heating\ Energy\ Savings\ [kWh]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton} \times Hours_{day}}{COP \times 3{,}412\ Btuh/kW}$$

Equation 89

$$Heating\ Energy\ Savings\ [kWh]_{Night} = \frac{CFM_{pre,night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton} \times Hours_{night}}{COP \times 3{,}412\ Btuh/kW}$$

Equation 90

$$Heating\ Energy\ Savings\ [kWh] = Cooling\ Energy\ Savings\ [kWh]_{Day} + Cooling\ Energy\ Savings\ [kWh]_{Night}$$

Equation 91

Electric Cooling Demand Savings (weighted by climate zone peak hour probability)

$$Summer\ Demand\ Savings\ [kW]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton}}{12{,}000\ Btuh/ton}$$

Equation 92

Electric Heating Demand Savings (weighted by climate zone peak hour probability)

$$Winter\ Demand\ Savings\ [kW]_{Day/Night} = \frac{CFM_{pre,day/night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton}}{COP \times 3{,}412\ Btuh/kW}$$

Equation 93

Where:

CFM_{pre}	=	*Calculated pre-retrofit air infiltration (cubic feet per minute)*
$CFM_{reduction}$	=	*59%[272] x TDF*
TDF	=	*Technical degradation factor = 85%[273]*
1.08	=	*Sensible heat equation conversion[274]*
ΔT	=	*Change in temperature across gap barrier (°F)*
$Hours_{day}$	=	*12-hour cycles per day, per month = 4,380 hours*
$Hours_{night}$	=	*12-hour cycles per night, per month = 4,380 hours*
COP	=	*Heating coefficient of performance; 1.0 for electric resistance and 3.3 for heat pumps*

Deemed Energy and Demand Savings Tables

Deemed energy and demand savings per linear foot of installed weather stripping or door sweep are specified below based on climate zone and existing door gap width. The length measurement should be initially measured to the nearest ¼ inch and converted to linear feet rounded to hundredths (0.02) including any segments that are not sealed due to corners, hinges, handles, or other obstructions. The width of the door gap should be rounded to nearest gap width in inches in Table 124 through Table 129. Heating savings are specified for both electric resistance (ER) and heat pump (HP) heating. Cooling savings are available for buildings with electric cooling and gas heat, but no heating savings should be claimed for buildings with gas heat.

Table 124. Deemed Cooling Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	1.90	3.83	7.60	11.42
Zone 2: Dallas	3.90	7.88	15.65	23.49
Zone 3: Houston	3.01	6.09	12.09	18.14
Zone 4: Corpus Christi	5.00	10.08	20.03	30.06
Zone 5: El Paso	2.81	5.69	11.28	16.93

[272] CLEAResult, "Commercial Door Air Infiltration Memo". March 18, 2015. Average reduction in Arkansas based on test results from the CLEAResult Brush Weather Stripping Testing Method and Results (59% infiltration reduction).

[273] This factor is applied to account for the difference between the laboratory test from the "Commercial Door Air Infiltration Memo" and the real-world ability to seal the openings around a door. In the absence of research regarding the actual difference, this factor was set to 0.85.

[274] 2013 ASHRAE Handbook of Fundamentals; Equation 33, p. 16.11.

Table 125. Deemed ER Heating Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	101.26	204.24	405.72	609.05
Zone 2: Dallas	48.90	98.82	196.15	294.44
Zone 3: Houston	27.18	55.06	109.19	163.91
Zone 4: Corpus Christi	22.78	46.02	91.35	137.13
Zone 5: El Paso	45.59	92.23	182.99	274.69

Table 126. Deemed HP Heating Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	30.69	61.89	122.94	184.56
Zone 2: Dallas	14.82	29.95	59.44	89.22
Zone 3: Houston	8.24	16.69	33.09	49.67
Zone 4: Corpus Christi	6.90	13.94	27.68	41.56
Zone 5: El Paso	13.81	27.95	55.45	83.24

Table 127. Deemed Summer Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	0.0053	0.0105	0.0210	0.0315
Zone 2: Dallas	0.0044	0.0090	0.0179	0.0269
Zone 3: Houston	0.0043	0.0087	0.0173	0.0259
Zone 4: Corpus Christi	0.0041	0.0082	0.0164	0.0246
Zone 5: El Paso	0.0041	0.0083	0.0165	0.0247

Table 128. Deemed ER Winter Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	0.0268	0.0541	0.1074	0.1612
Zone 2: Dallas	0.0412	0.0828	0.1648	0.2474
Zone 3: Houston	0.0211	0.0425	0.0844	0.1267
Zone 4: Corpus Christi	0.0190	0.0383	0.0762	0.1144
Zone 5: El Paso	0.0099	0.0202	0.0400	0.0602

Table 129. Deemed HP Winter Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	0.0138	0.0277	0.0550	0.0825
Zone 2: Dallas	0.0178	0.0357	0.0710	0.1066
Zone 3: Houston	0.0102	0.0207	0.0410	0.0615
Zone 4: Corpus Christi	0.0087	0.0175	0.0348	0.0523
Zone 5: El Paso	0.0049	0.0099	0.0197	0.0296

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 11 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID BS-Wthr.[275] This measure life is consistent with the residential air infiltration measure in the Texas TRM.

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
- Existing gap width (1/8", 1/4", 1/2", or 3/4")
- Installed measure (weather stripping or door sweep)
- Linear feet (to nearest 0.02 feet = 1/4") of installed weather stripping or door sweep

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.

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

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~Not applicable.~~

Document Revision History

Table 130. Nonresidential Entrance and Exit Door Air Infiltration Revision History

TRM version	Date	Description of change
v6.0	10/2018	TRM v6.0 origin.
v7.0	10/2019	TRM v7.0 update. Minor text revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Degradation factor added to deemed savings values. Guidance clarified for measuring gap sizes.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. No revisions.

2.4 NONRESIDENTIAL: FOOD SERVICE EQUIPMENT

2.4.1 ENERGY STAR® Combination Ovens Measure Overview

TRM Measure ID: NR-FS-CO

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Business Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

Eligible units must be compliant with the current ENERGY STAR® specifications, with half-size and full-size ovens as defined below and a pan capacity ≥ 5 and ≤ 20.[276, 277]

- ~~Half-size combination oven: capable of accommodating a single 12 x 20 x 2½-inch steam table pan per rack position, loaded from front-to-back or lengthwise.~~
- Full-size combination oven: capable of accommodating two 12.7 x 20.8 x 2~~½~~.5-inch steam table pans per rack position, loaded from front-to-back or lengthwise.
- Half-size combination oven: capable of accommodating a single 12.7 x 20.8 x 2.5-inch steam table pan per rack position, loaded from front-to-back or lengthwise.

[276] ENERGY STAR® Program Requirements for Commercial Ovens. Eligibility Criteria Version ~~2.2~~3.0. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.0%20Commercial%20Ovens%20Final%20Specification.pdf.~~https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf~~.

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

- ~~2/3~~Two-thirds-size combination ovens were added to the current ENERGY STAR® specification but are excluded from this measure until the ENERGY STAR® food service calculator is updated to include category-specific input assumptions.

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[278]

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

- ~~2/3-sized combination ovens~~
- Dual-fuel heat source combination ovens
- ~~Gas combination ovens~~
- ~~Electric combination ovens with a pan capacity < 5 or > 20~~
- Hybrid ovens not defined as eligible above (e.g., those incorporating microwave settings)
- Conventional or standard ovens, conveyor, slow cook-and-hold, deck, hearth, microwave, range, rapid cook, reel-type, and rotisserie
- Full and half-size gas combination ovens with a pan capacity of < 5 or > 40
- Full and half-size electric combination ovens with a pan capacity < 3 or > 40
- ~~2/3~~Two-thirds-size combination ovens with a pan capacity > 5
- Mini and quadruple gas rack ovens
- Electric rack ovens
- ~~Conventional or standard ovens, conveyor, slow cook-and-hold, deck, range, rapid cook, and rotisserie~~

Baseline Condition

The baseline condition for retrofit situations is a half-size or full-size combination oven with a pan capacity ≥ 5 and ≤ 20 that does not meet ENERGY STAR® key product criteria.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v~~2.2~~3.0 specification, effective ~~October 7, 2015~~January 12, 2023. Qualified products must meet the minimum energy efficiency and idle energy rate requirements from Table 131.

[278] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf.

Table 131. Combination Ovens—ENERGY STAR® Specification[279]

Operation	Idle rate (kW)[280]	Cooking energy efficiency (%)
~~Steam mode~~	~~≤ 0.133P + 0.6400~~	~~≥ 55~~
~~Convection mode~~	~~≤ 0.080P + 0.4989~~	~~≥ 76~~
Full-size and half-size ovens with 5-40 pan capacity		
Steam mode	≤ 0.133P + 0.64	≥ 55
Convection mode	≤ 0.083P + 0.35	≥ 78
Full-size and half-size ovens with 3-4 pan capacity		
Steam mode	≤ 0.60P	≥ 51
Convection mode	≤ 0.05P + 0.55	≥ 70

Furthermore, ~~P~~pan ~~C~~capacity[281] must be ≥ ~~5~~3 and ≤ ~~20~~ 40 (for both half- and full-size combination ovens). Pan capacity must be ≥ 3 and ≤ 5 for ~~2/3~~two-thirds-size combination ovens.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The deemed values are calculated by using the following algorithms:

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

Equation 94

$$kWh_{base} = kWh_{ph,base} + kWh_{conv,base} + kWh_{st,base}$$

Equation 95

$$kWh_{ES} = kWh_{ph,ES} + kWh_{conv,ES} + kWh_{st,ES}$$

Equation 96

kWh_{ph}, kWh_{conv} and kWh_{st} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in Equation 97, except they require their respective input assumptions

[279] ENERGY STAR® Commercial Ovens Key Product Criteria. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ovens/key_product_criteria.

[280] P = Pan Capacity.

[281] Pan Capacity is defined as the number of steam table pans the combination oven can accommodate as per the ASTM F-1495-05 standard specification.

relative to preheat, cooking and idle operation in convection and steam modes as seen in Table 132.

$$kWh = \left(E_{ph} + \left(\frac{W_{food} \times E_{food} \times 50\%}{\eta_{cook}}\right) + E_{idle} \times \left(\left(t_{on} - \frac{W_{food}}{PC}\right) \times 50\%\right)\right) \times \frac{t_{days}}{1000}$$

Equation 97

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

Equation 98

Where:

kWh_{base}	=	*Baseline annual energy consumption [kWh]*
kWh_{ES}	=	*ENERGY STAR® annual energy consumption [kWh]*
E_{ph}	=	*Preheat energy [Wh/BTU]*
ΔE_{ph}	=	*Difference in baseline and ENERGY STAR® preheat energy*
E_{food}	=	*ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]*
E_{Idle}	=	*Idle energy rate [W]*
W_{food}	=	*Pounds of food cooked per day [lb/day]*
η_{cook}	=	*Cooking energy efficiency [%]*
PC	=	*Production capacity per pan [lb/hr]*
t_{on}	=	*Equipment operating hours per day [hr/day]*
t_{days}	=	*Facility operating days per year [days/year]*
1000	=	*Constant to convert from W to kW*
CF	=	*Peak coincidence factor*

Table 132. Combination Ovens—ENERGY STAR® Commercial Food Service Calculator Inputs[282]

Parameter		Convection mode		Steam mode	
		Baseline	ENERGY STAR®	Baseline	ENERGY STAR®
E_{ph}	P < 15	3,000		1,500	
	P ≥ 15	3,750		2,000	

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

Parameter		Convection mode		Steam mode	
		Baseline	ENERGY STAR®	Baseline	ENERGY STAR®
W_{food}	P < 15	200			
	P ≥ 15	250			
E_{food}		73.2		30.8	
η_{cook}	3 ≥ P < 5	~~72~~70%	~~76~~70%	49%	~~55~~51%
	P ≥ 5	72%	78%	49%	55%
E_{idle}	3 ≥ P < 5~~P < 15~~	1,320	(0.05P + 0.55) x 1000~~(0.080P + 0.4989) x 1000~~	5,260	0.60P x 1000 ~~(0.133P + 0.6400) x 1000~~
	5 ≥ P < 15	1,320	(0.083P + 0.35) x 1000	5,260	(0.133P + 0.64) x 1000
	P ≥ 15	2,280		8,710	
PC[283]	P < 15	79	119	126	177
	P ≥ 15	166	201	295	349
t_{on}		12			
t_{days}		365			
CF[284]		0.90			

Deemed Energy and Demand Savings Tables

~~The following d~~Deemed energy and demand savings in Table 133 are based on the input assumptions from Table 132~~:~~.

Table 133. Combination Ovens—Deemed Energy and Demand Savings Values[285]

Pan capacity	Annual energy savings (kWh)	Peak demand savings (kW)
3	1,080	0.125
4	843	0.074
5	4,338~~4,015~~	0.789~~0.723~~
6	4,999~~4,677~~	0.923~~0.857~~

[283] The 3/2021 ENERGY STAR® calculator update no longer varies C_{cap} by pan capacity. However, this is assumed to be an error. The values specified for pan capacity of 15 or greater are specified in the previous calculator version.

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

[285] ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment Calculator: http://www.energystar.gov/buildings/sites/default/uploads/files/Commercial_kitchen_equipment_calculator.xlsx.

Pan capacity	Annual energy savings (kWh)	Peak demand savings (kW)
7	5,6775,356	1.0600.994
8	6,3706,051	1.2001.134
9	7,0796,761	1.3431.278
10	7,8047,488	1.4901.425
11	8,5458,231	1.6401.575
12	9,3038,990	1.7931.729
13	10,0769,765	1.9501.886
14	10,86510,556	2.1102.046
15	11,67011,363	2.2732.210
16	12,49212,187	2.4392.376
17	13,32913,026	2.6092.546
18	14,18213,881	2.7822.720
19	15,05114,753	2.9582.897
20	15,93715,640	3.1383.077
21	16,838	3.320
22	17,755	3.507
23	18,689	3.696
24	19,638	3.889
25	20,603	4.085
26	21,585	4.284
27	22,582	4.487
28	23,595	4.693
29	24,625	4.902
30	25,670	5.114
31	26,732	5.330
32	27,809	5.549
33	28,902	5.771
34	30,012	5.997
35	31,137	6.226
36	32,279	6.458
37	33,436	6.693
38	34,609	6.932
39	35,799	7.174

Pan capacity	Annual energy savings (kWh)	Peak demand savings (kW)
40	37,004	7.420

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-ElecCombOven.[286]

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.

- Manufacturer and model number
- Pan capacity
- ENERGY STAR® idle rate
- ENERGY STAR® cooking efficiency
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~ENERGY STAR® Equipment Standards for Commercial Ovens. http://www.energystar.gov/products/certified-products/detail/Commercial-ovens~~
- ~~DEER 2014 EUL update.~~

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

Document Revision History

Table 134. Nonresidential ENERGY STAR® Combination Ovens Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Updated previous method based upon the Food Service Technology Center (FSTC) assumptions to an approach using the newly developed ENERGY STAR® Commercial Ovens Program Requirements Version 2.1, which added combination ovens under this version. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v3.1	11/05/2015	TRM v3.1 update. Updated title to reflect ENERGY STAR® measure.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator updates. Corrected ENERGY STAR® idle rate formulas. Updated tracking system requirements and EUL reference.
v10.0	10/2022	TRM v10.0 update. Updated specification and deemed savings to comply with ENERGY STAR® Commercial Ovens Program Requirements Version 3.0.

2.4.2 ENERGY STAR® Electric Convection Ovens Measure Overview

TRM Measure ID: NR-FS-CV

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section covers the savings from retrofit or new installation of a full-size or half-size ENERGY STAR® electric convection ovens. Convection ovens cook their food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. The energy and demand savings are deemed and based on oven energy rates, cooking efficiencies, operating hours, production capacities, and building type. Average energy and demand consumption, used to calculate the savings, are determined using these assumed default input values on a per-oven basis.

Eligibility Criteria

Eligible units must be compliant with the current ENERGY STAR® specification, with half-size and full-size electric ovens as defined below:[287, 288]

- Full-size convection oven: capable of accommodating standard full-size sheet pans measuring 18 x 26 x 1-inch.
- Half-size convection oven: capable of accommodating half-size sheet pans measuring 18 x 13 x 1-inch.

[287] ENERGY STAR® Program Requirements for Commercial Ovens. Eligibility Criteria Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.0%20Commercial%20Ovens%20Final%20Specification.pdf~~https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf~~.

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

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[289]

Convection ovens eligible for rebate do not include ovens that can heat the cooking cavity with saturated or superheated steam. However, eligible convection ovens may have moisture injection capabilities (e.g., baking ovens and moisture-assist ovens). Ovens that include a "hold feature" are eligible under this specification if convection is the only method used to fully cook the food.

Products listed below are excluded from the ENERGY STAR® eligibility criteria:

- Half-size gas convection ovens
- Hybrid ovens not defined as eligible above (e.g., those incorporating microwave settings)-
- Conventional or standard ovens, conveyor, slow cook-and-hold, deck, hearth, microwave, range, rapid cook, reel-type, and rotisserie
- Mini and quadruple gas rack ovens
- Electric rack ovens
- Conventional or standard ovens, conveyor, slow cook-and-hold, deck, range, rapid cook, and rotisserie

Baseline Condition

The baseline condition for retrofit situations is an electric convection oven that does not meet ENERGY STAR® key product criteria.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v~~2.2~~3.0 specification, effective ~~October 7, 2015~~January 12, 2023. Qualified products must meet the minimum energy efficiency and idle energy rate requirements from Table 135.

[289] CEE Commercial Kitchens Initiative's overview of the food service industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf

Table 135. Convection Ovens—ENERGY STAR® Specification[290]

Oven size	Idle rate (W)	Cooking energy efficiency (%)
Full size ≥ 5 pans	≤ ~~1,600~~1,400	≥ ~~71~~76
Full size < 5 pans	≤ 1,000	
Half size	≤ 1,000	≥ 71

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

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

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

Equation 99

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

Equation 100

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

Equation 101

kWh_{ph}, kWh_{cook}, and kWh_{idle} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in Equation 102, except they require their respective input assumptions relative to preheat, cooking, and idle operation as seen in Table 136.

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

Equation 102

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

Equation 103

Where:

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

[290] ENERGY STAR® Commercial Ovens Key Product Criteria. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ovens/key_product_criteria.

kWh_{ES}	=	*ENERGY STAR® annual energy consumption [kWh]*
E_{ph}	=	*Preheat energy [Wh/BTU]*
ΔE_{ph}	=	*Difference in baseline and ENERGY STAR® preheat energy*
E_{food}	=	*ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]*
E_{Idle}	=	*Idle energy rate [W]*
W_{food}	=	*Pounds of food cooked per day [lb/day]*
η_{cook}	=	*Cooking energy efficiency [%]*
PC	=	*Production capacity [lb/hr]*
t_{on}	=	*Operating hours per day [hr/day]*
t_{days}	=	*Facility operating days per year [days/year]*
1000	=	*Constant to convert from W to kW*
CF	=	*Coincidence factor*

Table 136. Convection Ovens—ENERGY STAR® Commercial Food Service Calculator Inputs[291]

Parameter	Full size ≥ 5 pans		Full size < 5 pans		Half size	
	Baseline	ENERGY STAR®	Baseline	ENERGY STAR®	Baseline	ENERGY STAR®
E_{ph}	1,563	~~890~~1,389	1,563	1,389	890~~1,389~~	700
W_{food}	100					
E_{food}	73.2					
η_{cook}	65%	~~71~~76%	65%	76%	68%	70.67%
E_{idle}	2,000	~~1,600~~1,400	2,000	1,000	1,030	1,000
PC	90	90	90	90	45	50
t_{on}	12					
t_{days}	365					
CF[292]	0.90					

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

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

Deemed Energy and Demand Savings Tables

~~The following d~~Deemed energy and demand savings in Table 137 are based on the input assumptions from Table 136~~:~~.

Table 137. Convection Ovens—Deemed Energy and Demand Savings Values

Oven size	kWh	kW
Full size ≥ 5 pans	3,043~~2,001~~	0.612~~0.398~~
Full size < 5 pans	4,633	0.939
Half size	244	0.036

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-ElecConvOven.[293]

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.

- Manufacturer and model number
- Pan capacity
- Oven size
- ENERGY STAR® idle rate
- ENERGY STAR® cooking efficiency
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

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

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~ENERGY STAR® requirements for Commercial Ovens. http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens.~~
- ~~ENERGY STAR® list of Qualified Commercial Ovens. https://www.energystar.gov/productfinder/product/certified-commercial-ovens/results.~~
- ~~DEER 2014 EUL update.~~

Document Revision History

Table 138. Nonresidential ENERGY STAR® Convection Oven Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Updated to newer ENERGY STAR® Commercial Ovens Program Requirements Version 2.1. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v3.1	11/05/2015	TRM v3.1 update. Updated title to reflect ENERGY STAR® Measure.
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. Corrected convection oven definitions. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. Incorporated changes from March 2021 calculator update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Updated specification and deemed savings to comply with ENERGY STAR® Commercial Ovens Program Requirements Version 3.0.

2.4.3 ENERGY STAR® Dishwashers Measure Overview

TRM Measure ID: NR-FS-DW

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

Eligible units must be compliant with the current ENERGY STAR® specification and fall under one of the following categories.[294, 295] These categories are described in Table 139:

- Under counter dishwasher
- Stationary rack, single tank, door type dishwasher
- Single tank conveyor dishwasher

[294] ENERGY STAR® Program Requirements Product Specifications for Commercial Dishwashers. Eligibility Criteria Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/Commercial%20Dishwashers%20Final%20Version%203.0%20Specification_0_0.pdf.

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

- Multiple tank conveyor dishwasher
- Pot, pan, and utensil

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[296]

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

Additionally, though single- and multiple-tank flight-type conveyor dishwashing machines (where the dishes are loaded directly on the conveyor rather than transported within a rack—also referred to as a rackless conveyor) are eligible as per the version 3.0 specification, they are considered ineligible for this measure, since default values are not available for flight-type dishwashers in the ENERGY STAR® Commercial Kitchen Equipment Calculator.

Table 139. Dishwashers—ENERGY STAR® Equipment Type Descriptions

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

[296] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf

Equipment type	Equipment description
Multiple-tank conveyor dishwasher	A conveyor-type machine that has one or more tanks for wash water and one or more tanks for pumped rinse water, followed by a final sanitizing rinse. This type of machine may include one or more pre-washing sections before the washing section. Multiple-tank conveyor dishwashers can be either chemical or hot-water sanitizing, with an internal or external hot-water-booster heater for the latter.
Pot, pan, and utensil	A stationary-rack, door-type machine designed to clean and sanitize pots, pans, and kitchen utensils.

Baseline Condition

Baseline equipment is either a low-temperature[297] or high-temperature[298] machine as defined by Table 139, which is not used in a residential or laboratory setting. For low-temperature units, the DHW is assumed to be electrically heated. For high-temperature units, the DHW can either be heated by electric or natural gas methods. For units heated with natural gas, the unit shall have an electric booster heater attached to it.

High-Efficiency Condition

Qualifying equipment must be compliant with the current ENERGY STAR® v3.0 specification, effective July 27, 2021. High-temperature equipment sanitizes using hot water and requires a booster heater. Low-temperature equipment uses chemical sanitization and does not require a booster heater. Qualified products must be less than or equal to the maximum idle energy rate and water consumption requirements from Table 140.

Table 140. Dishwashers—ENERGY STAR® Specification[299]

Machine type	Low-temperature efficiency requirements		High-temperature efficiency requirements	
	Idle energy rate (kW)	Water consumption (gal/rack)	Idle energy rate (kW)	Water consumption (gal/rack)
Under counter	≤ 0.25	≤ 1.19	≤ 0.30	≤ 0.86
Stationary single-tank door	≤ 0.30	≤ 1.18	≤ 0.55	≤ 0.89
Single-tank conveyor	≤ 0.85	≤ 0.79	≤ 1.20	≤ 0.70
Multiple-tank conveyor	≤ 1.00	≤ 0.54	≤ 1.85	≤ 0.54
Pot, pan, and utensil	N/A	N/A	≤ 0.90	≤ 0.58[300]

[297] Low temperature machines apply a chemical sanitizing solution to the surface of the dishes to achieve sanitation.
[298] High temperature machines apply only hot water to the surface of the dishes to achieve sanitation.
[299] ENERGY STAR® Commercial Dishwashers Key Product Criteria. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers/key_product_criteria.
[300] Water consumption for pot, pan, and utensil is specified in gallons-per-square-foot rather than gallons-per-rack.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed savings values are calculated using the following algorithms:

$$Energy\ Savings\ [\Delta kWh] = (V_{base} - V_{ES}) \times \left(\frac{\Delta T_{DHW} + \Delta T_{boost}}{\eta_{DHW}}\right) \times \rho_{water} \times C_p \times \frac{1\ kWh}{3{,}412\ Btu} + (E_{idle,base} - E_{idle,ES}) \times \left(t_{~~hours~~on} - N_{racks} \times \frac{t_{wash}}{60}\right) \times t_{days}$$

Equation 104

$$V_{base} = t_{days} \times N_{racks} \times V_{rack,base}$$

Equation 105

$$V_{ES} = t_{days} \times N_{racks} \times V_{rack,ES}$$

Equation 106

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

Equation 107

Where:

ρ_{water}	=	*Density of water [lb/gallon]*
C_p	=	*Specific heat of water [Btu/lb °F]*
ΔT_{DHW}	=	*Inlet water temperature increase for building water heater [°F]*
ΔT_{boost}	=	*Inlet water temperature for booster water heater [°F]*
η_{DHW}	=	*Building electric water heater and booster heater efficiency [%]*
N_{racks}	=	*Number of racks washed per days*
V_{base}	=	*Baseline annual volume of water consumption [gal/year]*
V_{ES}	=	*ENERGY STAR® annual volume of water consumption [gal/year]*
$V_{rack,base}$	=	*Baseline per rack volume of water consumption [gal/rack]*
$V_{rack,ES}$	=	*ENERGY STAR® per rack volume of water consumption [gal/rack]*
$E_{Idle,base}$	=	*Baseline idle energy rate [kW]*
$E_{Idle,ES}$	=	*ENERGY STAR® idle energy rate [kW]*
t_{wash}	=	*Wash time per rack [min]*
t_{on}	=	*Equipment operating hours per day [hr/day]*
t_{days}	=	*Facility operating days per year [days/year]*
3,412	=	*Constant to convert from Btu to kWh*

60 = *Constant to convert from minutes to hours*

CF = *Peak coincidence factor*

Table 141. Dishwashers—ENERGY STAR® Commercial Food Service Calculator Inputs[301]

Inputs	Under counter	Single-door type	Single-tank conveyor	Multiple-tank conveyor	Pot, pan, and utensil
ρ_{water}					61.4 ÷ 7.48 = 8.2
C_p					1.0
ΔT_{DHW}					Gas water heaters: 0ºF Electric water heaters: 70 ºF
ΔT_{boost}					Gas booster heaters: 0 ºF Electric booster heaters: 40 ºF
η_{DHW}					98%
t_{on}					18
t_{days}					365
CF[302]					0.90
Low-temperature units					
N_{racks}	75	280	400	600	--
$V_{rack,base}$	1.73	2.10	1.31	1.04	--
$V_{rack,ES}$	1.19	1.18	0.79	0.54	--
$E_{idle,base}$	0.50	0.60	1.60	2.00	--
$E_{idle,ES}$	0.25	0.30	0.85	1.00	--
t_{wash}	2.0	1.5	0.3	0.3	--
High-temperature units					
N_{racks}	75	280	400	600	280
$V_{rack,base}$	1.09	1.29	0.87	0.97	0.70
$V_{rack,ES}$	0.86	0.89	0.70	0.54	0.58
$E_{idle,base}$	0.76	0.87	1.93	2.59	1.20
$E_{idle,ES}$	0.30	0.55	1.20	1.85	0.90
t_{wash}	2.0	1.0	0.3	0.2	3.0

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

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

Deemed Energy and Demand Savings Tables

~~The following d~~Deemed energy and demand savings in Table 142 are based on the input assumptions from Table 141~~:~~.

Table 142. Dishwashers—Deemed Energy and Demand Savings Values

Facility description	Under counter		Stationary single-tank door		Single-tank conveyor		Multiple-tank conveyor		Pot, pan, and utensil	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Low temp./ electric water heater	3,955	0.542	17,362	2.378	17,426	2.387	24,292	3.328	--	--
High temp./ electric water heater with electric booster heater	4,303	0.589	12,596	1.726	10,966	1.502	29,751	4.075	3,750	0.514
High temp./ gas water heater with electric booster heater	3,221	0.441	5,572	0.763	6,700	0.918	13,569	1.859	1,642	0.225
High temp./ electric water heater with gas booster heater	3,684	0.505	8,582	1.176	8,528	1.168	20,504	2.809	2,545	0.349

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) varies per eligible dishwasher type, as stated in the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.

Table 143. Dishwashers—Equipment Lifetime by Machine Type

Machine type	EUL (years)
Under counter	10
Stationary single-tank door	15
Single-tank conveyor	20
Multiple-tank conveyor	20
Pot, pan, and utensil	10

Program Tracking Data and Evaluation Requirements

The 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:

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

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~ENERGY STAR® requirements for Commercial Dishwashers. https://www.energystar.gov/sites/default/files/asset/document/Commercial%20Dishwashers%20Final%20Version%203.0%20Specification_0_0.pdf.~~
- ~~ENERGY STAR® maintains an online list of qualified Commercial dishwashers meeting or exceeding ENERGY STAR® requirements at http://www.energystar.gov/productfinder/product/certified-Commercial-dishwashers/results.~~
- ~~ENERGY STAR® v2.0 Calculator (Commercial Kitchen Equipment Savings Calculator). http://www.energystar.gov/buildings/sites/default/uploads/files/Commercial_kitchen_equipment_calculator.xlsx.~~

Document Revision History

Table 144. Nonresidential ENERGY STAR® Dishwashers Revision History

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

TRM version	Date	Description of change
v3.0	04/30/2015	TRM v3.0 update. Aligned calculation approach with ENERGY STAR® Commercial Dishwashers Program Requirements Version 2.0. Simplified methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	TRM v4.0 update. Added high-efficiency requirements for pots, pans, and utensils.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Updated ENERGY STAR® specification and incorporated March 2021 calculator update. Updated variable definitions.
v10.0	10/2022	TRM v10.0 update. Corrected mismatch between formula definitions and variables. Replaced URL for ENERGY STAR® listing.

2.4.4 ENERGY STAR® Hot Food Holding Cabinets Measure Overview

TRM Measure ID: NR-FS-HC

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section covers the deemed savings methodology for the installation of ENERGY STAR® hot food holding cabinets (HFHCs). An HFHC is a heated, fully enclosed compartment with one or more solid or transparent doors designed to maintain the temperature of hot food that has been cooked using a separate appliance. HFHCs that have earned ENERGY STAR® certification incorporate better insulation, thus reducing heat loss, and may also offer additional energy-saving devices such as magnetic door gaskets, auto-door closers, or Dutch doors. The insulation of the cabinet offers better temperature uniformity within the cabinet from top to bottom. The energy and demand savings are deemed and based on an interior volume range of the holding cabinets and the building type. An average wattage has been calculated for each volume range, half size, three-quarter size, and full size. The energy and demand savings are determined on a per-cabinet basis.

Eligibility Criteria

HFHCs must be compliant with the current ENERGY STAR® specification.[303, 304] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[305]

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

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

[305] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf.

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

- Dual function equipment (e.g., "cook-and-hold" and proofing units)
- Heated transparent merchandising cabinets
- Drawer warmers

Baseline Condition

The baseline condition is a half-size, three-quarter size, or full-size hot food holding cabinet that do not meet ENERGY STAR® key product criteria.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v2.0 specification, effective October 1, 2011. Table 145 summarizes idle energy rate requirement based on cabinet interior volume.

Table 145. HFHCs—ENERGY STAR® Specification[306,307]

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

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

Deemed values are calculated using the following algorithms:

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

Equation 108

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

Equation 109

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

[307] V = Interior Volume = Interior Height x Interior Width x Interior Depth.

Where:

V	=	*Product interior volume [ft^3]*
$E_{Idle,base}$	=	*Baseline idle energy rate [W]*
$E_{Idle,ES}$	=	*ENERGY STAR® idle energy rate after installation [W]*
t_{on}	=	*Equipment operating hours per day [hrs/day]*
t_{days}	=	*Facility operating days per year [days/year]*
1000	=	*Constant to convert from W to kW*
CF	=	*Peak coincidence factor*

Table 146. HFHCs—ENERGY STAR® Commercial Food Service Calculator Inputs[308]

Input variable	Product interior volume range		
	0 < V < 13	13 ≤ V < 28	28 ≤ V
V[309]	8	22	53
$E_{Idle,base}$			30 × V
$E_{Idle,ES}$	21.5 × V	2 × V + 254	3.8 × V + 203.5
t_{on}			9
t_{days}			365
CF[310]			0.90

Deemed Energy and Demand Savings Tables

~~The following d~~Deemed energy and demand savings in Table 147 are based on the input assumptions from Table 146~~:~~.

Table 147. HFHCs—Deemed Energy and Demand Savings Values

Product interior volume (ft^3)	Annual energy savings (kWh)	Peak demand savings (kW)
0 < V < 13	223	0.061
13 ≤ V < 28	1,189	0.326

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

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

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

28 ≤ V	3,893	1.067

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-HoldCab.[311]

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:

- Manufacturer and model number
- Interior cabinet volume
- ENERGY STAR® idle 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

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

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

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

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

Document Revision History

Table 148. Nonresidential ENERGY STAR® Hot Food Holding Cabinets Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Updated to newer ENERGY STAR® Hot Food Holding Cabinet Program Requirements Version 2.0. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update. Updated EUL reference.
V10.0	10/2022	TRM v10.0 update. Minor formatting.

2.4.5 ENERGY STAR® Electric Fryers Measure Overview

TRM Measure ID: NR-FS-EF

Market Sector: Commercial

Measure Category: Cooking Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

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

Eligibility Criteria

Eligible units must meet be compliant with the current ENERGY STAR® specification, either counter-top or floor type designs, with standard-size and large vat fryers as defined below:[312, 313]

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

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[314]

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[312] ENERGY STAR® Program Requirements Product Specifications for Commercial Fryers. Eligibility Criteria Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/Commercial%20Fryers%20Program%20Requirements.pdf.

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

[314] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf.

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

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

Baseline Condition

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

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v3.0 specification, effective October 1, 2016. New electric standard fryers ≥ 12 inches and < 18 inches wide and large vat fryers > 18 inches and < 24 inches wide that meet or exceed the requirements listed in Table 149.

Table 149. Fryers—ENERGY STAR® Specification[315]

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed values are calculated using the following algorithms:

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

Equation 110

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

Equation 111

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

Equation 112

kWh_{ph}, kWh_{cook}, and kWh_{idle} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in Equation 113, except they require their respective input assumptions relative to preheat, cooking, and idle operation as seen in Table 150.

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

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

Equation 113

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

Equation 114

Where:

kWh_{base}	=	*Baseline annual energy consumption [kWh]*
kWh_{ES}	=	*ENERGY STAR® annual energy consumption [kWh]*
E_{ph}	=	*Preheat energy [Wh/~~BTU~~day]*
ΔE_{ph}	=	*Difference in baseline and ENERGY STAR® preheat energy*
E_{food}	=	*ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]*
E_{Idle}	=	*Idle energy rate [W]*
W_{food}	=	*Pounds of food cooked per day [lb/day]*
η_{cook}	=	*Cooking energy efficiency [%]*
PC	=	*Production capacity [lb/hr]*
t_{on}	=	*Equipment operating hours per day [hr/day]*
t_{ph}	=	*Preheat time [min/day]*
t_{days}	=	*Facility operating days per year [days/year]*
60	=	*Constant to convert from min to hr*
1000	=	*Constant to convert from W to kW*
CF	=	*Peak coincidence factor*

Table 150. Fryers—ENERGY STAR® Commercial Food Service Calculator Inputs[316]

Parameter	Standard-sized vat		Large vat	
	Baseline	ENERGY STAR®	Baseline	ENERGY STAR®
E_{ph}	2,400	1,900	2,400	1,900
W_{food}				150
E_{food}				167
η_{cook}	75%	83%	70%	80%
E_{idle}	1,200	800	1,350	1,100
PC	65	70	100	110
t_{on}		16		12
t_{ph}				15
t_{days}				365
CF[317]				0.90

Deemed Energy and Demand Savings Tables

~~The following d~~Deemed energy and demand savings in Table 151 ~~of~~ are based on the assumptions from Table 150~~:~~.

Table 151. Fryers—Deemed Energy and Demand Savings Values

Fryer type	Annual energy savings (kWh)	Peak demand savings (kW)
Standard	3,272	0.476
Large vat	2,696	0.516

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-ElecFryer.[318]

[316] ENERGY STAR® Commercial Food Service Equipment Calculator. 7/15/21 amendment to March 2021 update. https://www.energystar.gov/products/commercial_food_service_equipment.
[317] Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.
[318] 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:

- Manufacturer and model number
- Fryer width
- ENERGY STAR® idle rate
- ENERGY STAR® cooking efficiency
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for Electric Fryers.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~ENERGY STAR® requirements for Electric Fryers https://www.energystar.gov/sites/default/files/asset/document/Commercial%20Fryers%20Program%20Requirements.pdf~~
- ~~DEER 2014 EUL update.~~

Document Revision History

Table 152. Nonresidential ENERGY STAR® Electric Fryers Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Updated to newer ENERGY STAR® Electric Fryers Program Requirements Version 2.1. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Savings and efficiencies revised for ENERGY STAR® 3.0 specifications. Program tracking requirements updated.

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Minor variable definition updates.

2.4.6 ENERGY STAR® Electric Steam Cookers Measure Overview

TRM Measure ID: NR-FS-SC

Market Sector: Commercial

Measure Category: Cooking Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section covers the deemed savings methodology for the installation of ENERGY STAR® electric steam cookers. Steam cookers are available in 3-, 4-, 5-, or ≥ 6-pan capacities. Steam cookers that have earned ENERGY STAR® certification are up to 50 percent more efficient than standard models. They have higher production rates and reduced heat loss due to better insulation and a more efficient steam delivery system. The energy and demand savings are determined on a per-cooker basis.

Eligibility Criteria

Eligible units must be compliant with the current ENERGY STAR® specification.[319, 320] Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[321]

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

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

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

[321] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf.

Baseline Condition

The eligible baseline condition for retrofit situations is an electric steam cooker that does not meet ENERGY STAR® key product criteria.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v1.2 specification, effective August 1, 2003. Qualified products must meet the requirements from Table 153.

Table 153. Steam Cookers—ENERGY STAR® Specification[322]

Pan capacity	Cooking energy efficiency (%)[323]	Idle rate (W)
3-pan	50%	400
4-pan	50%	530
5-pan	50%	670
6-pan and larger	50%	800

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

Equation 115

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

Equation 116

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

Equation 117

kWh_{ph}, kWh_{cook}, and kWh_{idle} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in Equation 102, except they require their respective input assumptions relative to preheat, cooking, and idle operation as seen in Table 154.

[322] ENERGY STAR® Commercial Steam Cookers Key Product Criteria. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_steam_cookers/key_product_criteria.

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

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

Equation 118

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

Equation 119

Where:

kWh_{base}	=	*Baseline annual energy consumption [kWh]*
kWh_{ES}	=	*ENERGY STAR® annual energy consumption [kWh]*
E_{ph}	=	*Preheat energy [Wh/~~BTU~~day]*
ΔE_{ph}	=	*Difference in baseline and ENERGY STAR® preheat energy*
E_{food}	=	*ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]*
E_{Idle}	=	*Idle energy rate [W]. (Differs for boiler-based and steam-generator equipment)*
W_{food}	=	*Pounds of food cooked per day [lb/day]*
η_{cook}	=	*Cooking energy efficiency [%] (Differs for boiler-based or steam generator equipment)*
40%	=	*Percent of time in constant steam mode [%]*
PC	=	*Production capacity [lb/hr]*
P	=	*Pan capacity*
t_{on}	=	*Equipment operating hours per day [hr/day]*
t_{days}	=	*Facility operating days per year [days/year]*
1000	=	*Constant to convert from W to kW*
CF	=	*Peak coincidence factor*

Table 154. Steam Cookers—ENERGY STAR® Commercial Food Service Calculator Inputs[324]

Parameter	Baseline value	ENERGY STAR® value
E_{ph}	1,776	1,671.7
W_{food}		100
E_{food}		30.8
η_{cook}	Boiler-based: 26% Steam generator: 30%	50%
E_{Idle}	Boiler-based: 1,000 Steam generator: 1,200	3-pan: 400 4-pan: 530 5-pan: 670 6-pan: 800
PC	23.3	16.7
P		3, 4, 5, or 6
t_{on}		9.25
t_{days}		311
CF[325]		0.90

Deemed Energy and Demand Savings Tables

~~The following d~~Deemed energy and demand savings in Table 155 are based on the input assumptions from Table 154~~:~~.

Table 155. Steam Cookers—Deemed Energy and Demand Savings Values

Steam cooker type	P	Annual energy savings (kWh)	Peak demand savings (kW)
Boiler-based	3-pan	7,988	2.489
	4-pan	9,822	3.063
	5-pan	11,614	3.623
	6-pan and larger	13,408	4.185
Steam generator	3-pan	6,715	2.091
	4-pan	8,139	2.536
	5-pan	9,515	2.967
	6-pan and larger	10,891	3.397

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

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

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 12 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Cook-ElecStmCooker.[326]

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:

- Manufacturer and model number
- Steam cooker type (boiler-based or steam generator)
- Pan capacity (3, 4, 5, or 6+)
- ENERGY STAR® idle rate
- ENERGY STAR® cooking efficiency
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

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

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

- ~~ENERGY STAR® specifications for Commercial Steam Cookers. https://www.energystar.gov/sites/default/files/specs/private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf.~~
- ~~DEER 2014 EUL update.~~

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

Document Revision History

Table 156. Nonresidential ENERGY STAR® Electric Steam Cookers Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Updated EUL based on ENERGY STAR® and DEER 2014.
v3.0	04/10/2015	TRM v3.0 update. Updated to newer ENERGY STAR® Steam Cooker Program Requirements Version 1.2. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed ENERGY STAR® qualification requirement and defers to meeting criteria.
v9.0	10/2021	TRM v9.0 update. Incorporated March 2021 calculator update. Corrected formula errors. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Corrected formula error and minor variable definition updates.

2.4.7 ENERGY STAR® Ice Makers Measure Overview

TRM Measure ID: NR-FS-IM

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: Any commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section covers the deemed savings methodology for the installation of ENERGY STAR® automatic ice makers installed in commercial sites.

Eligibility Criteria

Eligible equipment includes air-cooled batch and continuous ice makers with the following design types: ice-making head (IMH), self-contained (SCU), and remote condensing (RCU) units. Eligible units must be compliant with the current ENERGY STAR® specification.[327, 328]

Any commercial-type building is eligible; building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[329]

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

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

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

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

[329] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf.

Baseline Condition

The baseline condition is an ice maker meeting the federal standards published in 10 CFR 431 listed in Table 157. The baseline applies to automatic air-cooled commercial ice maker with capacities between 50 and 4,000 pounds per 24-hour period manufactured on or after January 28, 2018.

Table 157. Ice Makers—Federal Standard[330]

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

[330] Code of Federal Regulations, Title 10 Part 431.136 for air-cooled batch-type and continuous-type automatic commercial ice maker with capacities between 50 and 4,000 pounds per 24-hour period manufactured on or after January 28, 2018. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=53.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v3.0 specification, effective January 28, 2018. Qualified products must meet the minimum energy consumption (kWh/100 lbs ice) from Table 158.

Table 158. Ice Makers—ENERGY STAR® Specification[331]

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

Energy and Demand Savings Methodology

Average harvest rates per design-type were computed for both batch and continuous ice makers utilizing the ENERGY STAR® qualified products listing for commercial ice makers for the purpose of possibly establishing deemed savings but were determined to be too variable. Therefore, savings for air-cooled batch and continuous commercial ice makers are dependent on the harvest rate and can be calculated using the following algorithms:

[331] ENERGY STAR® Commercial Ice Maker Key Product Criteria . https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria.

Savings Algorithms and Input Variables

$$Energy\ Savings\ [\Delta kWh] = (E_{base} - E_{\mathrm{ES}}) \times \frac{H}{100} \times DC \times t_{days}$$

Equation 120

$$Peak\ Demand\ [\Delta kW] = \Delta kWh\ \times PLS$$

Equation 121

Where:

E_{base}	=	*Baseline rated energy consumption (kWh) per 100 pounds of ice, Table 157*
E_{ES}	=	*ENERGY STAR® rated energy consumption (kWh) per 100 pounds of ice, see Table 158*
H	=	*Harvest rate in pounds of ice produced per 24 hours*
DC	=	*Machine duty cycle, 75%*[332]
t_{days}	=	*Number of days per year, default is 365 based on continuous use for both batch and continuous type ice makers.*
PLS	=	*Probability-weighted peak load share, see Table 159*

Table 159. Ice Makers—Probability-Weighted Peak Load Share

Probability weighted peak load share (PLS)[333]		
Climate zone	Summer peak	Winter peak
1	0.00012	0.00011
2		
3		
4		0.00012
5		

Deemed Energy Savings Tables

There are no deemed energy savings tables for this measure.

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

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

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.[334]

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

Please refer to measure citations for 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.~~

[334] 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 160. 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.
v10.0	10/2022	TRM v10.0 update. No revisions.

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 and buildings with commercial kitchens

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.[335] 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).[336] This output is adjusted by population to account for the percentage of sites with electric resistance or heat pump heating.[337] Additionally, because output from the OALC is per 1,000 CFM, a CFM per HP ratio[338] 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

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

Equation 122

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

Equation 123

Where:

$HP_{exhaust}$	=	*Total exhaust horsepower of the kitchen ventilation system included in the DCV operating strategy, facility-specific*
IHS	=	*Interactive heating savings per 1,000 CFM of outdoor air; see Table 162*
$AvgSav_{kWh/HP}$	=	*Average hourly energy savings per horsepower* ~~*based on*~~

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

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

[337] 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.

[338] 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.

~~the~~ by building type, see Table 161

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

DOH~~Hrs_{day}~~ = Average daily operating hours, facility specific; if unknown, use defaults from Table 161

AOD~~$Days_{yr}$~~ = ~~Number of operational days per year~~Annual operating days, facility specific; if unknown use defaults from Table 161

MAU = Make-up Air Unit factor applied to account for presence of dedicated MAU; value = 1 if there is a dedicated MAU; see Table 161 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 ~~W~~weighted ~~P~~peak ~~L~~load ~~S~~share; see Table 163

Table 161. 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[339]	~~0.650~~0.667	15	365	0.65
24-hr restaurant/hotel[340]	0.631	24	365	0.65
School café with summer[341]	0.566	11	325	0.51
School café without summer	0.566	11	252	0.51

Table 162. 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

[339] Pennsylvania TRM, "3.5.3 High-Efficiency Fan Motors for Walk-In Refrigerated Cases". Page 369, Table 3-93. June 2016.
[340] All values are the average of Hotel Restaurant data from Future of DCV for Commercial Kitchens.
[341] 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 161.

Climate zone	Building type	Interactive savings (kWh/hp)
	School café with summer	838
	School café without summer	409
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 163. Demand Controlled Kitchen Ventilation—Probability Weighted Peak Load Share[342]

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 164. 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

[342] 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
	School café with summer	2,864	1,881
	School café without summer	1,981	1,218
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 165. 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.[343]

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

Please refer to measure citations for relevant standards and reference sources.

~~Not applicable.~~

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

Document Revision History

Table 166. 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.
v10.0	10/2022	TRM v10.0 update. Formula updates and correct table error.

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 168

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 167 (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 167.[344]

Table 167. ~~Pre-Rinse Spray Valve~~ PRSVs – 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

[344] 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.[345] 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 167 for the pre-rinse spray valve's respective product class. The sprayer should be capable of the same cleaning ability as the old sprayer.[346]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy and demand savings are calculated using the following algorithms:

$$Energy\ Savings\ [\Delta kWh] = \frac{\mathrm{U} \times (F_B - F_P) \times \mathrm{AOD} \times (T_H - T_C) \times \rho \times C_P}{RE \times 3{,}412} \mathrm{U} \times (F_{\cancel{B}} - F_{\cancel{P}}) \times \frac{\cancel{Days}}{\cancel{Year}} \times (T_{\cancel{H}} - T_{\cancel{C}}) \times C_{\cancel{H}} \times \frac{C_{\cancel{E}}}{Eff_{\cancel{E}}}$$

Equation 124

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

Equation 125

Where:

U	=	*Water usage duration, see Table 168*
F_B	=	*Baseline flow rate of sprayer (GPM), see Table 167*
F_P	=	*PRSV~~, 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 (ºF),*

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

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

		140.5°F[347]
T_C	=	Average supply (cold) water temperature (ºF), 71.4°F[348]
~~Days~~AOD	=	~~Annual f~~Facility annual operating days ~~for the applications~~, see Table 168
~~ρC_H~~	=	~~Unit conversion for w~~Water density: 8.33 lbs/gallon
C_P	=	Specific heat of water, 1 Btu/lb°F
~~C_E~~	=	~~Unit conversion: 1 BTU = 0.00029308 kWh (1/3412)~~
RE~~E~~ff$_E$	=	Recovery efficiency of an electric water heater, 0.98[349]
HPLS/100,000	=	Hourly ~~peak demand as percent of daily demand probability-weighted~~ peak load share, see Table 169

Table 168. PRSVs – Assumed Variables for Energy and Demand Savings Calculations

Variable	Assumed value
U[350]	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
AOD~~Days~~[351]	Fast food restaurant: 360 Casual dining restaurant: 360 Institutional: 360 Dormitory: 270 K-12 school: 193

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

[348] 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.

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

[350] "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.

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

Table 169. PRSVs – Probability-Weighted Hourly Peak Load Share[352]

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.[353]

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

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

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

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

Please refer to measure citations for relevant standards and reference sources.

~~Not applicable.~~

Document Revision History

Table 170. 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.
v10.0	10/2022	TRM v10.0 update. Formula and variable definition updates.

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.[354] The study included four supermarket chains, with three sites selected for each chain. Each test site operated approximately 20 hours per day. Package sealers were located in deli, meat, and or produce departments. Power data was measured in 10-second intervals over a six-week monitoring period. A low sample interval was chosen to accurately capture the pulsing of the heating elements.

The study estimated demand savings by averaging power draw during the peak hours from 2-5 PM to account for the cycling of the larger heating element on the on-demand unit. This measure uses 10-minute average load shape to estimate coincidence factors consistent with the Texas peak definition.[355] This approach is more consistent with the 15-minute interval data typically used in calculated demand and energy charges by utilities. Demand savings are calculated by dividing energy savings by 8,760 and multiplying against the coincidence factor.

Deemed Energy and Demand Savings Tables

Table 171. 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.[356]

[354] "Vacuum-Sealing and Packaging Machines for Food Service Field Test, ET13SCE1190 Report," SCE & FTSC. December 2014. https://www.etcc-ca.com/sites/default/files/reports/ET10SCE1450%20Vacuum%20Sealing%20Packaging%20Machine%20Report_Final.pdf.

[355] See Volume 1, Section 4.

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

Program Tracking Data and Evaluation Requirements

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

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

References and Efficiency Standards

Petitions and Rulings

None.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

~~Not applicable.~~

Document Revision History

Table 172. 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.
v10.0	10/2022	TRM v10.0 update. No revisions.

2.5 NONRESIDENTIAL: REFRIGERATION

2.5.1 Door Heater Controls Measure Overview

TRM Measure ID: NR-RF-HC

Market Sector: Commercial

Measure Category: Refrigeration

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

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of door heater controls for glass-door refrigerated cases with anti-sweat heaters (ASH). A door heater controller senses dew point (DP) temperature in the store and modules power supplied to the heaters accordingly. DP inside a building is primarily dependent on the moisture content of outdoor ambient air. Because the outdoor DP varies between climate zones, weather data from each climate zone must be analyzed to obtain a DP profile. The reduced heating results in a reduced cooling load. The savings are on a per-horizontal-linear-foot-of-display-case basis.

Eligibility Criteria

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

Baseline Condition

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

High-Efficiency Condition

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

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

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

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

Equation 126[357]

The baseline assumes door heaters are running on an 8,760-hour operating schedule. In the post-retrofit case, the duty for each hourly reading is calculated by assuming a linear relationship between indoor DP and duty cycle for each bin reading. It is assumed that the door heaters will be all off (duty cycle of 0%) at 42.89ºF DP and all on (duty cycle of 100%) at 52.87ºF DP for a typical supermarket.[358] Between these values, the door heaters' duty cycle changes proportionally:

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

Equation 127

The controller only changes the run-time of the heaters, so the instantaneous door heater power (kW_{ASH}) as a resistive load remains constant per linear foot of door heater[359] at:

For medium temperature (coolers):

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

Equation 128

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

[358] Ibid, "Direct ASH Power", page 6.
42.89ºF DP and 52.87ºF DP correspond to relative humidity of 35 percent and 50 percent, respectively, for a 72ºF indoor space. These relative humidity values are common practice setpoints for a typical supermarket of this temperature.

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

[360] Ibid.

For low temperature (freezers):

kW_{ASH} = *0.191 per door or 0.0764 per horizontal linear foot of door*[361]

Equation 129

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

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

Equation 130

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

Equation 131

To calculate energy savings from the reduced refrigeration load using average system efficiency and assuming that 35 percent of the anti-sweat heat becomes a load on the refrigeration system,[362] the cooling load contribution from door heaters for each hour of the year can be given by:

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

Equation 132

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.[363]

[361] Ibid.

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

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

For medium temperature compressors, the following equation is used to determine 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 133[364]

Where:

a	=	*3.75346018700468*
b	=	*-0. 049642253137389*
c	=	*29.4589834935596*
d	=	*0.000342066982768282*
e	=	*-11.7705583766926*
f	=	*-0.212941092717051*
g	=	*-1.46606221890819 x 10^{-6}*
h	=	*6.80170133906075*
I	=	*-0.020187240339536*
j	=	*0.000657941213335828*
PLR	=	*1/1.15 = 0.87*
SCT	=	*T_{db} + 15*
T_{DB}	=	*Dry-bulb temperature*

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

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

Equation 134[365]

Where:

a	=	*9.86650982829017*
b	=	*-0.230356886617629*
c	=	*22.905553824974*

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

[365] Ibid.

d	=	*0.00218892905109218*
e	=	*-2.48866737934442*
f	=	*-0.248051519588758*
g	=	*-7.57495453950879 x 10^{-6}*
h	=	*2.03606248623924*
i	=	*-0.0214774331896676*
j	=	*0.000938305518020252*
PLR	=	*1/1.15 = 0.87*
SCT_{LT}	=	T_{db} *+10*
T_{DB}	=	*Dry-bulb temperature*

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 135

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

Equation 136

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 137

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

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

Equation 138

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;[366] Table 173 provides these deemed values.

Table 173. 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.[367]

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

[366] http://texasefficiency.com/index.php/regulatory-filings/deemed-savings
[367] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

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

Please refer to measure citations for relevant standards and reference sources.

- ~~DEER 2014 EUL update~~
- ~~TMY3 Hourly Weather Data by Climate Zone~~[368]

Document Revision History

Table 174. 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 133 and Equation 134.
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.
v10.0	10/2022	TRM v10.0 update. No revisions.

[368] ~~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, schools[369], 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.

[369] Refrigeration and freezer units utilized in a school setting typically function year-round. This operating schedule prevents malfunctioning due to periods of prolonged disuse and allows child nutrition meal programs offered to students and the community to operate during school off-seasons. Schools are therefore an applicable building type for this measure, which utilizes annual operating hours derived from a full-year schedule.