Energy Savings Algorithms

For the RUL time period:

$$kWh_{savings,ER} = kWh_{manf} - kWh_{ES}$$

Equation 140

For the remaining time in the EUL period, calculate annual savings as you would for a replace-on-burnout project:

$$kWh_{savings,ROB} = kWh_{baseline} - kWh_{ES}$$

Equation 141

Where:

kWh_{manf} = 805~~841~~ kWh/Year[497]

Demand Savings Algorithms

To calculate demand savings for the early retirement of a freezer, a similar methodology is used as for replace-on-burnout installations, with separate savings calculated for the remaining useful life of the unit, and the remainder of the EUL as outlined in the section above.

For the RUL time period:

$$kW_{savings,ER} = \frac{kWh_{savings,ER}}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 142

[497] ~~This is the weighted average of adjusted annual unit energy consumption, a metric obtained from the MwEPA Refrigerator and Freezer Energy Rating Database (if from metering, substitute recorded value in lieu of this weighted average). Weights are calculated from the millions-of-households measurements obtained from RECS, (https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.6.php) corresponding to the year range classifications of freezers greater than 15 years old (specifically, 15-to-19-years-old and 20-or-more-years-old). The oldest freezers for which we had data were from 1979.~~Existing unit consumption is derived from the MwEPA Refrigerator and Freezer Database. Consumption is weighted using appliance characteristics from the 2020 Residential Energy Consumption Survey (RECS) for units greater than 15 years old. Data was only available for units manufactured on or after 1979. https://www.energy.gov/scep/wap/articles/refrigerator-and-freezer-energy-rating-online-search-tool. https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%203.8.pdf.

For the remaining time in the EUL period, calculate annual savings as you would for a replace-on-burnout project:

$$kW_{savings,ROB} = \frac{kWh_{savings,ROB}}{8{,}760\ hrs} \times CF_{S/W}$$

Equation 143

Annual deemed summer peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

Deemed Energy Savings Tables

Table 368. Freezers—Savings (kWh)

Freezer type	Size	ROB savings (kWh)	ER savings (kWh)
Chest	Standard (≥ 7.75 ft^3)	29	154
	Compact (< 7.75 ft^3)	22	163
Upright	Standard (≥ 7.75 ft^3)	48	130
	Compact (< 7.75 ft^3)	32	151

Deemed Summer Demand Savings Tables

Table 369. Freezers—Replace-on-Burnout—Summer Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.004	0.004	0.004	0.004	0.004
	Compact (< 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003
Upright	Standard (≥ 7.75 ft^3)	0.006	0.006	0.006	0.006	0.006
	Compact (< 7.75 ft^3)	0.004	0.004	0.004	0.004	0.004

Table 370. Freezers—Early Retirement—Summer Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.020	0.019	0.019	0.019	0.019
	Compact (< 7.75 ft^3)	0.021	0.020	0.021	0.020	0.020
Upright	Standard (≥ 7.75 ft^3)	0.017	0.016	0.016	0.016	0.016
	Compact (< 7.75 ft^3)	0.019	0.019	0.019	0.019	0.019

Deemed Winter Demand Savings Tables

Table 371. Freezers—Replace-on-Burnout—Winter Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003
	Compact (< 7.75 ft^3)	0.002	0.002	0.002	0.002	0.002
Upright	Standard (≥ 7.75 ft^3)	0.005	0.005	0.005	0.005	0.005
	Compact (< 7.75 ft^3)	0.003	0.003	0.003	0.003	0.003

Table 372. Freezers—Early Retirement—Winter Peak Demand Savings (kW)

Freezer type	Product class	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Chest	Standard (≥ 7.75 ft^3)	0.016	0.017	0.016	0.017	0.017
	Compact (< 7.75 ft^3)	0.017	0.018	0.017	0.018	0.018
Upright	Standard (≥ 7.75 ft^3)	0.014	0.014	0.014	0.014	0.014
	Compact (< 7.75 ft^3)	0.016	0.017	0.016	0.016	0.017

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is established at 22 years based on the current DOE Final Rule standards for residential freezers.[498]

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Baseline type (new construction, replace-on-burnout, or early retirement)
- Manufacturer and model number
- Freezer type (upright or chest)
- Freezer size (standard, i.e., ≥ 7.75 ft^3, or compact, i.e., < 7.75 ft^3)
- Photograph demonstrating functionality of existing equipment and/or customer responses to survey questionnaire documenting the condition of the replaced unit and their motivation for measure replacement for early retirement eligibility determination (early retirement only)
- The installer will provide documentation of proper disposal of freezers in accordance with applicable federal, state, and local regulations (early retirement only)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

[498] Final Rule: Standards, Federal Register, 76 FR 57516 (Sept. 15, 2011) and associated Technical Support Document. https://www.ecfr.gov/cgi-bin/text-idx?SID=48f64e166fe3561666f871e521996e13&mc=true&node=se10.3.430_132&rgn=div8. Download TSD at: https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128.

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

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Document Revision History

Table 373. Freezers—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. Updated early retirement age eligibility.
v9.0	10/2021	TRM v9.0 update. Updated early retirement age eligibility.
v10.0	10/2022	TRM v10.0 update. Updated early retirement age eligibility.
v11.0	10/2023	TRM v11.0 update. Updated early retirement age eligibility.
v12.0	10/2024	TRM v12.0 update. Updated early retirement age eligibility and weighting using latest RECs data. Clarified upcoming federal standard.

2.5.7 Refrigerator/Freezer Recycling Measure Overview

TRM Measure ID: R-AP-RR

Market Sector: Residential

Measure Category: Appliance Recycling

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Early retirement

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves early retirement and recycling of an existing, full-size (7.75 ft^3 or greater) refrigerator or combined refrigerator/freezer in a residential application. Savings represent the entire estimated energy consumption of the existing unit and are applicable over the estimated remaining life of the existing unit.

Eligibility Criteria

This measure applies to operable primary and secondary retired refrigerators/freezers. Recycling savings for this measure are limited to the removal of a working refrigerator/freezer from the electrical grid and differ from the savings specified in the ENERGY STAR Refrigerator replacement measure. The latter, which pertain to the direct replacement of a refrigerator and reflect the difference in energy consumption between new ENERGY STAR qualifying and standard efficiency models, may be claimed for the recycling of primary refrigerators/freezers that have been replaced if savings for that replacement were not already claimed in another energy efficiency program. To qualify, the customer must release the existing unit to the utility or utility representative to ensure proper disposal in accordance with applicable federal, state, and local regulations.

Baseline Condition

Without program intervention, the recycled refrigerator or refrigerator/freezer would have remained operable on the electrical grid. As a result, the baseline condition for early retirement programs is continued operation of the existing refrigerator.

High-Efficiency Condition

There is no efficiency standard for a recycling measure because the energy efficient action is the removal of an operable appliance, not—as with most demand-side management programs—the installation of a higher efficiency model.

Energy and Demand Savings Methodology

The basis for estimating energy savings is the annual energy consumption of the refrigerator or refrigerator/freezer being retired.

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings are calculated as follows:

$$Energ\ Savings\ [\Delta kWh] = kWh_{existig} \times ISAF \times PUF$$

Equation 144

Where:

$kWh_{existing}$	=	*Average annual energy consumption[499] (see Table 374)*
ISAF	=	*In situ adjustment factor[500] = 0.942*
PUF	=	*Part use factor[501] = 0.915*

Table 374. Refrigerator/Freezer Recycling—Average Annual Energy Consumption

Total capacity (ft^3)	Year manufactured	$kWh_{existing}$ by freezer configuration				
		Top	Bottom	Side	Upright	Chest
< 16.5	≤ 2000	861	962	1,139	937	532
	2001-2010	556	724	747	713	435
	≥ 2011	374	483	592	449	292

[499] ENERGY STAR Flip Your Fridge Calculator. https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator.

[500] The Cadmus Group, Inc. "Residential Retrofit High Impact Measure Evaluation Report". Prepared for California Public Utilities Commission Energy Division. February 8, 2010. Factor to account for variation between site conditions and controlled DOE testing conditions (90 °F test chamber, empty refrigerator and freezer cabinets, and no door openings). Appliances in warmer climate zones use more energy than those in cooler climate zones; utilized SCE data (highest percentage of warm climate projects) to best approximate Texas climate, p. 139-140.

[501] Ibid. Factor to account for the number of refrigerators that were running, running part time, or not running at the time of recycling, p. 142-143 (weighted by representative utility survey participation, p. 117).

Total capacity (ft^3)	Year manufactured	$kWh_{existing}$ by freezer configuration				
		Top	Bottom	Side	Upright	Chest
16.5-18.9	≤ 2000	962	1,051	1,266	1,058	621
	2001-2010	613	747	818	805	508
	≥ 2011	412	517	640	507	341
19.0-21.4	≤ 2000	1,031	1,110	1,329	1,138	680
	2001-2010	651	762	854	866	557
	≥ 2011	438	539	664	545	373
21.5-24.4	≤ 2000	1,090	1,172	1,368	1,194	721
	2001-2010	683	777	876	909	591
	≥ 2011	459	562	679	572	396
≥ 24.5	≤ 2000	1,223	1,347	1,528	1,355	840
	2001-2010	758	822	966	1,031	688
	≥ 2011	508	627	740	648	461

Demand Savings Algorithms

Summer peak demand savings are calculated as follows:

$$Peak\ Demand\ Svings\ [\Delta \text{kW}] = \frac{\Delta kWh}{AOH} \times CF_{S/W}$$

Equation 145

Where:

AOH = *Annual operating hours = 8,760 hours*

$CF_{S/W}$ = *Seasonal coincidence factor (see Table 375)*

Table 375. Refrigerator/Freezer Recycling—Coincidence Factors[502]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	1.112	1.099	1.108	1.100	1.081
Winter	0.929	0.966	0.924	0.941	0.966

[502] See Volume 1, Appendix B.

Deemed Energy Savings Tables

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

Deemed Summer Demand Savings Tables

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

Deemed Winter Demand Savings Tables

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

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

Based on the KEMA Residential Refrigerator Recycling Ninth Year Retention Study,[503] the Estimated Useful Life of Refrigerator Recycling is 8 years, representing the assumed remaining useful life of the retired unit.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Number of refrigerators/freezers removed
- Year removed unit manufactured
- Total capacity (in cubic feet)
- Freezer configuration (top, bottom, side-by-side, upright, or chest)

[503] KEMA, Inc. "Residential Refrigerator Recycling Ninth Year Retention Study." Prepared for Southern California Edison Company. July 22, 2004.

References and Efficiency Standards

Petitions and Rulings

- Docket No. 42212. Petition of El Paso Electric Company to Approve Revisions to the Deemed Savings for the Appliance Recycling Market Transformation program. Public Utility Commission of Texas.

Relevant Standards and Reference Sources

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

Document Revision History

Table 376. Refrigerator/Freezer Recycling—Revision History

TRM version	Date	Description of change
v2.1	1/30/2015	TRM v2.1 origin.
v3.0	4/10/2015	TRM v3.0 update. CF updated to align with new peak demand methodology.
v3.1	11/05/2015	TRM v3.1 update. No revision.
v3.1	3/28/2016	TRM v3.1 March revision. Updated summer and winter CFs.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Updated baseline energy consumption.
v9.0	10/2021	TRM v9.0 update. Correct deemed ranges for refrigerator volume.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

2.5.8 ENERGY STAR® Air Purifiers Measure Overview

TRM Measure ID: R-AP-AP

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Replace-on-burnout, new construction

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the accepted deemed savings awarded for the installation of an ENERGY STAR air purifier. Savings are awarded at a flat per-unit rate, both for energy and demand savings. This measure will apply to existing homes and new construction.

Eligibility Criteria

This measure applies to floor, tabletop, and wall-mounted air purifiers/room air cleaners.

Baseline Condition

The baseline condition is the current federal standard Tier 1 requirements, effective August 9, 2023, with compliance enforced as of December 31, 2023. The standard will increase to Tier 2 requirements on December 31, 2025.[504]

Table 377. Air Purifiers—Federal Standard

Smoke CADR	Tier 1 CADR/W	Tier 2 CADR/W
10–99	1.7	1.9
100–149	1.9	2.4
150+	2.0	2.9

[504] DOE minimum efficiency standard for residential air cleaners. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=77. https://www.energy.gov/sites/default/files/2023-03/air-cleaners-ecs-dfr.pdf.

High-Efficiency Condition

The table below displays the ENERGY STAR Final Version 2.0 Requirements for eligible room air cleaners effective October 17, 2020, and revised May 2022.[505] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Table 378. Air Purifiers—ENERGY STAR Requirements

Smoke CADR	Minimum CADR/W
10–99	1.9
100–149	2.4
150+	2.9

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR Appliance Savings Calculator and the revised ENERGY STAR specification in Table 348.[506] Default baseline standby power and clean air delivery rate (CADR) efficiency (CADR/W) values were taken from the ENERGY STAR calculator. ENERGY STAR standby power, CADR, and CADR/W are averages from the ENERGY STAR qualified product listing. Baseline CADR is assumed to be equivalent to ENERGY STAR CADR.

This measure will be updated to comply with the latest available ENERGY STAR specification and appliance calculator. It will also periodically be updated to comply with the latest updates to the ENERGY STAR qualified product listing.

$$Energy\ Savings\ [\Delta kWh] = (kWh_{baseline,OP} + kWh_{baseline,SB}) - (kWh_{ES,OP} + kWh_{ES,SB})$$

Equation 146

$$kWh_{baseline,OP} = \left(\frac{CADR_{baseline}}{\eta_{baseline}}\right)/1{,}000 \times hours \times days$$

Equation 147

$$kWh_{baseline,SB} = (8{,}760 - hours \times days) \times \frac{W_{baseline,SB}}{1{,}000}$$

Equation 148

[505] ENERGY STAR Room Air Cleaners Final Version 2.0 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%202.0%20Room%20Air%20Cleaners%20Specification%20%28Rev.%20May%202022%29_0.pdf.

[506] ENERGY STAR Appliance Savings Calculator (updated October 2016). The previously cited URL is no longer available, but a copy of the calculator can be provided upon request.

$$kWh_{ES,OP} = \left(\frac{CADR_{ES}}{\eta_{ES}}\right)/1{,}000 \times hours \times days$$

Equation 149

$$kWh_{ES,SB} = (8{,}760 - hours \times days) \times \frac{W_{ES,SB}}{1{,}000}$$

Equation 150

Where:

$kWh_{baseline,OP}$ =		*Baseline/conventional operating energy usage*
$kWh_{baseline,SB}$	=	*Baseline/conventional standby energy usage*
$kWh_{ES,OP}$	=	*ENERGY STAR average operating energy usage*
$kWh_{ES,SB}$	=	*ENERGY STAR average standby energy usage*
$CADR_{baseline}$	=	*Baseline unit clean air delivery rate (cu ft/min), assume equivalent to* $CADR_{ES}$
$CADR_{ES}$	=	*ENERGY STAR unit clean air delivery rate (cu ft/min) (see Table 380)*
$\eta_{baseline}$	=	*Baseline clean air delivery efficiency = 1.0 cfm/W*
η_{ES}	=	*ENERGY STAR air delivery efficiency (cfm/W) (see Table 380)*
hours	=	*Average hours of operation per day = 16*
days	=	*Average days of operation per year = 365*
$W_{baseline,SB}$	=	*Conventional model standby power = 1.0 W*
$W_{ES,SB}$	=	*ENERGY STAR model standby power = 0.6 W*
1,000	=	*Constant to convert from W to kW*
8,760	=	*Total hours per year*

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{hours \times days} \times CF_{S/W}$$

Equation 151

Where:

$CF_{S/W}$	=	*Seasonal peak coincidence factor (see Table 379)*

Table 379. Air Purifiers—Coincidence Factors[507]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.636	0.617	0.631	0.620	0.564
Winter	0.882	0.907	0.829	0.876	0.926

Deemed Energy Savings Tables

Table 380. Air Purifiers—Energy Savings (kWh)

Smoke CADR range (cu ft/min)	ENERGY STAR QPL Average Smoke CADR	ENERGY STAR QPL Average Smoke CADR/W	kWh savings
10–99	75	3.0	115
100–149	129	4.3	222
150–199	171	4.6	284
200–249	225	4.4	363
250–299	275	5.7	522
300+	375	5.5	699

Deemed Summer Demand Savings Tables

Table 381. Air Purifiers—Summer Peak Demand Savings (kW)

Smoke CADR range (cu ft/min)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
10–99	0.012	0.012	0.012	0.012	0.011
100–149	0.024	0.023	0.024	0.024	0.021
150–199	0.031	0.030	0.031	0.030	0.027
200–249	0.040	0.038	0.039	0.039	0.035
250–299	0.057	0.055	0.056	0.055	0.051
300+	0.076	0.074	0.076	0.074	0.068

[507] See Volume 1, Section 4.

Deemed Winter Demand Savings Tables

Table 382. Air Purifiers—Winter Peak Demand Savings (kW)

Smoke CADR range (cu ft/min)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
10–99	0.017	0.018	0.016	0.017	0.018
100–149	0.034	0.034	0.032	0.033	0.035
150–199	0.043	0.044	0.040	0.043	0.045
200–249	0.055	0.056	0.052	0.054	0.058
250–299	0.079	0.081	0.074	0.078	0.083
300+	0.106	0.109	0.099	0.105	0.111

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 9 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID RES-AirCleaner.[508]

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- ENERGY STAR certificate matching model number
- Smoke clean air delivery rate (CADR) in cu ft/min (cfm)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

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

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 383. Air Purifiers—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Final Version 2.0 Requirements. Updated dust CADR references to refer to smoke CADR. Updated deemed savings ranges and values.
v11.0	10/2023	TRM v11.0 update. Updated baseline to Tier 1 federal standard.
v12.0	10/2024	TRM v12.0 update. ~~Updated baseline to Tier 1 federal standard.~~No revision.

2.5.9 ENERGY STAR® Dehumidifiers

TRM Measure ID: R-AP-DH

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of an ENERGY STAR-compliant dehumidifier.

Eligibility Criteria

Eligible equipment includes both portable and whole-home dehumidifiers that are compliant with the current ENERGY STAR specification.[509]

Baseline Condition

The baseline condition for this measure is a new dehumidifier that meets the current federal standard, effective June 13, 2019.[510] These standards are provided in Table 384 for portable dehumidifiers and Table 385 for whole-home dehumidifiers.

High-Efficiency Condition

The high-efficiency condition is a dehumidifier that meets the ENERGY STAR Version 5.0 Program Requirements for Dehumidifiers, effective October 31, 2019.[511] Units meeting ENERGY STAR Most Efficient 2020 Criteria are eligible for additional savings. These standards are provided in Table 384 and Table 385.

[509] ENERGY STAR Dehumidifier Qualified Product Listing. https://www.energystar.gov/productfinder/product/certified-dehumidifiers/results.

[510] Energy Conservation Program: Energy Conservation Standards for Dehumidifiers. https://www.federalregister.gov/documents/2022/06/22/2022-13322/energy-conservation-program-energy-conservation-standards-for-dehumidifiers

[511] ENERGY STAR Version 5.0 Program Requirements for Dehumidifiers. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20Version%205.0%20Program%20Requirements_0.pdf.

A new ENERGY STAR Final Version 6.0 specification will be effective October 1, 2025.[512] Texas TRM v13 will be updated for compliance with that updated specification.

Table 384. Dehumidifiers—Federal and ENERGY STAR standards for Portable Dehumidifiers

Product Capacity (pints/day)	Federal Standard Criteria (L/kWh)	ENERGY STAR IEF (L/kWh)	ENERGY STAR Most Efficient (L/kWh)
≤ 25	≥ 1.30	≥ 1.57	≥ 1.70
> 25 to ≤ 50	≥ 1.60	≥ 1.80	≥ 1.90
> 50	≥ 2.80	≥ 3.30	≥ 3.40

Table 385. Dehumidifiers—Federal and ENERGY STAR standards for Whole-Home Dehumidifiers

Case Volume (ft^3)	Federal Standard IEF (L/kWh)[513]	ENERGY STAR IEF (L/kWh)	ENERGY STAR Most Efficient (L/kWh)
≤ 8.0	≥ 1.77	≥ 2.09	≥ 2.22
> 8.0	≥ 2.41	≥ 3.30	≥ 3.40

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

The annual energy savings are calculated using the following equation:

$$Annual\ Energy\ Savings\ [\Delta kWh] = \frac{Cap\ \times 0.473}{24} \times HOU \times \left(\frac{1}{L/kWh_{Base}} - \frac{1}{L/kWh_{ES}}\right)$$

Equation 152

Where:

Cap = *Average product capacity (pints/day), from ENERGY STAR (See Table 386)*

0.473 = *Constant to convert from pints to liters*

24 = *Constant to convert from from hours to days*

[512] ENERGY STAR Version 6.0 Program Requirements for Dehumidifiers. https://www.energystar.gov/sites/default/files/2024-08/ENERGY%20STAR%20Dehumidifiers%20V6.0%20Final%20Specification%20with%20Partner%20Commitments.pdf.

[513] ENERGY STAR Dehumidifiers Key Efficiency Criteria. https://www.energystar.gov/products/appliances/dehumidifiers/key_efficiency_criteria.

HOU = *Hours of use per year [hours][514] = 1,632*

L/kWh_{base} = *Baseline liters of water per kWh consumed (see Table 384 and Table 385)*

L/kWh_{ES} = *ENERGY STAR liters of water per kWh consumed (see Table 386)*

Table 386. Dehumidifiers—Savings Calculation Input Assumptions[515]

Dehumidifier Type	Most Efficient	Capacity Range (pints/day)	ENERGY STAR Avg Capacity (pints/day)	ENERGY STAR Avg Efficiency (L/kWh)
Portable	No	≤ 25	22.0	1.63
	No	> 25 to ≤ 50	43.0	1.85
	Yes	≤ 25	20.8	1.78
	Yes	> 25 to ≤ 50	44.5	2.01
Whole-Home	No	Any	79.1	2.13
	Yes	Any	82.8	2.35

Demand Savings Algorithms

No winter peak demand electric savings are calculated for this measure.

The summer peak electric demand savings are calculated using the following equation.

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{Savings}}{HOU} \times CF_S$$

Equation 153

Where:

CF_S = *Summer peak coincidence factor (See Table 356)*

Table 387. Dehumidifiers—Coincidence Factors[516]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.355	0.345	0.353	0.346	0.315
Winter [517]	0.000	0.000	0.000	0.000	0.000

[514] ENERGY STAR calculator, assuming 24 hour operation over 68 days of the year. Updated October 1, 2016.
[515] Values were averaged from August 2024 ENERGY STAR Dehumidifier QPL. No items on QPL had capacities above 50 pints/day for portable dehumidifiers, or case volumes larger than 8 ft^3 for whole-home dehumidifiers, so these size ranges are excluded.
[516] See Volume 1, Section 4.
[517] The ENERGY STAR appliance calculator only assumes operation April through September.

Deemed Energy Savings Tables

Table 388. Dehumidifiers—Annual Energy Savings (kWh)

Dehumidifier Type	Most Efficient	Capacity (pints/day)	Energy Savings
Portable	No	≤ 25	110
	No	> 25 to ≤ 50	117
	Yes	≤ 25	139
	Yes	> 25 to ≤ 50	182
Whole-Home	No	Any	243
	Yes	Any	371

Deemed Summer Demand Savings Tables

Table 389. Dehumidifiers—Summer Peak Demand Savings (kW)

Dehumidifier Type	Most Efficient	Capacity (pints/day)	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Portable	No	≤ 25	0.024	0.023	0.024	0.023	0.021
	No	> 25 to ≤ 50	0.025	0.025	0.025	0.025	0.023
	Yes	≤ 25	0.030	0.029	0.030	0.030	0.027
	Yes	> 25 to ≤ 50	0.040	0.038	0.039	0.039	0.035
Whole-Home	No	Any	0.053	0.051	0.053	0.052	0.047
	Yes	Any	0.081	0.078	0.080	0.079	0.072

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for Dehumidifiers is 12 years.[518]

[518] ENERGY STAR Dehumidifier Calculator based on 2012 EPA Research.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- ENERGY STAR Most Efficient status (yes, no)
- Type of dehumidifier (portable, whole-home)
- Capacity/size of the new and old unit (pints/day)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

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 390. Dehumidifiers—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

2.5.10 ENERGY STAR® Ventilation Fans

TRM Measure ID: R-AP-VF

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of ENERGY STAR-compliant bathroom and utility room ventilation fans.

Eligibility Criteria

Eligible equipment includes ventilation fans that are compliant with the current ENERGY STAR specification.[519] The new ventilation fans must also have a capacity that is between 10 CFM and 500 CFM.

Baseline Condition

ENERGY STAR does not specify a baseline efficacy for existing residential ventilation fans. Therefore, a conservative improvement of 15 percent for the efficient case is used to determine the baseline. The resulting baseline efficacy values are provided in Table 391.

Table 391. Ventilation Fans—Baseline Bathroom and Utility Room Ventilating Fan Efficacy

Air Flow (CFM)	Baseline Efficacy (CFM/Watt)
10-89	2.4
90-200	3.0
201-500	3.4

[519] ENERGY STAR Ventilation Fan Qualified Product Listing. https://www.energystar.gov/products/ventilation_fans.

High-Efficiency Condition

The high-efficiency condition is a ventilation fan that meets the ENERGY STAR Version 4.1 Program Requirements for Residential Ventilating Fans, effective October 1, 2015.[520] These standards are provided in Table 384 and Table 393.

Table 392. Ventilation Fans—ENERGY STAR Minimum Efficacy Levels

Air Flow (CFM)	ENERGY STAR	ENERGY STAR Most Efficient
	Minimum Efficacy Level (CFM/W)	
10-89	≥ 2.8	≥ 10.0
90-200	≥ 3.5	
201-500	≥ 4.0	

Table 393. Ventilation Fans— ENERGY STAR Maximum Sound Levels

Air Flow (CFM)	ENERGY STAR	ENERGY STAR Most Efficient
	Maximum Sound Level (Sones)	
10-200	< 2.0	< 4.0
201-500	< 3.0	

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

The annual energy savings are calculated using the following equation:

$$Annual\ Energy\ Savings\ [\Delta kWh] = Cap \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ES}}\right) \times \frac{1}{1{,}000} \times AOH$$

Equation 154

Where:

Cap = *Nominal ENERGY STAR capacity of the exhaust fan (use maximum value for multi-speed fans) [CFM]*

η_{base} = *Baseline fan efficacy (CFM/Watt), (see Table 391)*

η_{ES} = *ENERGY STAR fan efficacy (CFM/Watt) (see Table 394)*

[520] ENERGY STAR Version 4.1 Program Requirements for Residential Ventilating Fans. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Ventilating%20Fans%20Specification%20Version%204.2.pdf.

AOH = *Annual operating hours[521] = 438*

1,000 = *Constant to convert from W to kW*

Table 394. Ventilation Fans – ENERGY STAR Average Airflow and Efficacy[522]

Air Flow (CFM)	Most Efficient	ENERGY STAR Avg Airflow (CFM)	ENERGY STAR Avg Efficacy (CFM/Watt)
10-89	No	72	5.6
90-300		117	6.3
201-500		295	4.4
10-89	Yes	68	12.0
90-300		128	11.7
201-500		260	6.7

Demand Savings Algorithms

No winter peak electric demand savings are calculated for this measure.

The summer peak electric demand savings are calculated using the following equation.

$$Peak\ Demand\ Savings\ [\Delta kW] = CFM \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ES}}\right) \times \frac{1}{1{,}000} \times CF$$

Equation 155

Where:

CF = *Seasonal peak coincidence factor (see Table 395)*

Table 395. Ventilation Fans—Coincidence Factors[523]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.060	0.053	0.063	0.059	0.032
Winter	0.275	0.232	0.199	0.263	0.358

[521] "Residential Lighting End-Use Consumption Study: Estimateion Framework and Initial Estimates". U.S. Department of Energy. December 2012. Page 50. Bathroom lights estimated to run 1.2 hours day, or 438 hours per year (1.2 x 365 = 438), assuming ventilation fan operation when the bathroom light was on. https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf.

[522] Values were averaged from August 2024 ENERGY STAR Ventilation Fans QPL.

[523] See Volume 1, Section 4. Using values from the Residential Lighting measure.

Deemed Energy Savings Tables

Table 396. Ventilation fans - Annual Energy Savings (kWh)

Air Flow (CFM)	Most Efficient	Energy Savings (kWh)
10-89	No	8
90-300		9
201-500		9
10-89	Yes	10
90-300		14
201-500		16

Deemed Summer Demand Savings Tables

Table 397. Ventilation Fans – Summer Peak Demand Savings (kW)

Air Flow (CFM)	Most Efficient	Climate Zone 1:	Climate Zone 2:	Climate Zone 3:	Climate Zone 4:	Climate Zone 5:
		Amarillo	Dallas	Houston	Corpus Christi	El Paso
10-89	No	0.0010	0.0009	0.0011	0.0010	0.0005
90-300	No	0.0012	0.0011	0.0013	0.0012	0.0007
201-500	No	0.0012	0.0010	0.0012	0.0012	0.0006
10-89	Yes	0.0014	0.0012	0.0014	0.0013	0.0007
90-300	Yes	0.0019	0.0017	0.0020	0.0019	0.0010
201-500	Yes	0.0023	0.0020	0.0024	0.0022	0.0012

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for a ventilation fan is 19 years.[524]

[524] "Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures". Prepared by GDS Associates for the New England State Program Working Group (SPWG). June 2007. Table 1, Page 1-3. Conservative estimate based 25-year EUL for for whole-house fans and 19-year EUL for thermostatically-controlled attic fans. https://energizect.com/sites/default/files/documents/Measure%20Life%20Report%202007.pdf.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- ENERGY STAR Most Efficient status (yes, no)
- Nominal capacity of the ventilation fan
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

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 398. Ventilation Fans—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

2.5.11 ENERGY STAR® Water Coolers

TRM Measure ID: R-AP-WC

Market Sector: Residential

Measure Category: Appliances

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of ENERGY STAR-compliant water coolers. Water coolers are a home appliance that offer consumers the ability to enjoy hot and/or cold water on demand.

Eligibility Criteria

Eligible equipment includes water coolers that are compliant with the current ENERGY STAR specification.[525]

This measure applies to bottled water and point-of-use units, conditioned storage water coolers and on-demand water coolers, and products that provide sparkling, alkaline, or flavored water in addition to chilled water. Units that provide pressurized water and are not freestanding, are air-source or use a water source other than bottled or tap water, and units that are primarily ice makers with a water dispensing function are ineligible under this measure.

Water coolers must be installed in a residential application.

Baseline Condition

The baseline condition is a non-ENERGY STAR-certified water cooler.

[525] ENERGY STAR Water Coolers Qualified Product Listing (QPL). https://www.energystar.gov/products/water_coolers.

High-Efficiency Condition

The high-efficiency condition is a water heater that meets the ENERGY STAR Version 3.0 Program Requirements for Water Coolers, effective March 23, 2022.[526]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

$$Energy\ Savings\ [\Delta kWh] = (kWh_{base} - kWh_{ES}) \times AOD$$

Equation 156

Where:

kWh_{base} = *Daily energy use for baseline water cooler [kWh/day] (see)*

kWh_{ES} = *Daily energy use for ENERGY STAR water cooler [kWh/day] (see)*

AOD = *Annual operating days[527] = 365*

Table 399. Water Coolers—Baseline & Efficient Water Cooler Daily Energy Use (kWh/day)

Type of Water Cooler	kWh_{base}[528]	kWh_{ES}[529]
Hot and Cold Water (Storage)	0.891	0.695
Hot and Cold Water (On Demand)	0.183	0.143
Cold Water Only	0.184	0.144

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{8{,}760} \times CF_{S/W}$$

Equation 157

[526] ENERGY STAR Version 3.0 Program Requirements for Water Coolers. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Verison%203.0%20Water%20Coolers%20Final%20Specification_0.pdf.

[527] Assumed 365 days per year and 24 hours per day as utilized in daily energy consumption from ENERGY STAR Program Requirements Product Specification 3.0 for Water Coolers Test Method.

[528] Assuming a baseline energy consumption of 22% greater than the ENERGY STAR specification. https://www.energystar.gov/products/water_coolers.

[529] Average ratings from certified products on ENERGY STAR Water Coolers Qualified Product Listing. https://www.energystar.gov/products/water_coolers.

Where:

$CF_{S/W}$ = *Seasonal coincidence factor (See Table 401)*

8,760 = *Total hours per year*

Table 400. Water Coolers—Coincidence Factors[530]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	1.112	1.099	1.108	1.100	1.081
Winter	0.929	0.966	0.924	0.941	0.966

Deemed Energy Savings Tables

Table 401. Water Coolers—Energy Savings (kWh)

Type of Water Cooler	kWh
Hot and Cold Water (Storage)	72
Hot and Cold Water (On Demand)	15
Cold Water Only	

Deemed Summer Demand Savings Tables

Table 402. Water Coolers—Summer Peak Demand Savings (kW)

Type of Water Cooler	kW
Hot and Cold Water (Storage)	0.009
Hot and Cold Water (On Demand)	0.002
Cold Water Only	

Deemed Winter Demand Savings Tables

Table 403. Water Coolers—Winter Peak Demand Savings (kW)

Type of Water Cooler	kW
Hot and Cold Water (Storage)	0.008
Hot and Cold Water (On Demand)	0.002
Cold Water Only	

Claimed Peak Demand Savings

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

[530] See Volume 1, Section 4. Using values from the Residential Refrigerators measure.

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for an ENERGY STAR water cooler is 5 years based on the maximum observed manufacturer warranty period for products on the ENERGY STAR QPL.[531]

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- Type of water cooler (storage, on demand)
- Water temperature (hot and cold, cold water only)
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

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 404. Water Coolers—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin.

[531] Oasis Coolers had the most products rated on the ENERGY STAR QPL when accessed on 9/11/2024. https://www.oasiscoolers.com/service-support/warranty-information.html.

2.5.12 ENERGY STAR® Pool Pumps Measure Overview

TRM Measure ID: R-AP-PP

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the replacement of a single-speed pool pump with an ENERGY STAR-certified variable-speed or multi-speed pool pump.

Eligibility Criteria

This measure applies to all residential applications of in-ground pools or above-ground pools. Pools that serve multiple tenants in a common area are not eligible for this measure. Ineligible pump products include waterfall, integral cartridge filter, integral sand filter, storable electric spa, and rigid electric spa.[532]

Multi-speed pool pumps are an alternative to variable speed pumps. The multi-speed pump uses an induction motor that functions as two motors in one, with full-speed and half-speed options. Multi-speed pumps may enable significant energy savings. However, if the half-speed motor is unable to complete the required water circulation task, the larger motor will operate exclusively. Having only two speed-choices limits the ability of the pump motor to fine-tune the flow rates required for maximum energy savings.[533] Therefore, multi-speed pumps must have a high-speed override capability to revert to low speed after a period not to exceed 24 hours.

[532] These product types are excluded by the ENERGY STAR specification. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification_0.pdf.

[533] Hunt, A. and Easley, S., 2012, "Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings." Building America Retrofit Alliance (BARA), US DOE. May 2012. http://www.nrel.gov/docs/fy12osti/54242.pdf.

Baseline Condition

The baseline is assumed to be a new pool pump that is compliant with the current federal standard, effective July 19, 2021.[534] Weighted energy factor (WEF) requirements are based on rated hydraulic horsepower (hhp).

Table 405. Pool Pumps—Baseline Condition~~—Federal Standard Effective July 19, 2021~~

Pump subtype	Size class	WEF
Self-priming (inground) pool pumps	Extra small (hhp ≤ 0.13)	WEF = 5.55
	Small (hhp > 0.13 to < 0.711)	WEF = -1.30 x ln(hhp) + 2.90
	Standard (hhp ≥ 0.711)	WEF = -2.30 x ln(hhp) + 6.59
Non-self priming (above ground) pool pumps	Extra small (hhp ≤ 0.13)	WEF = 4.60
	Standard size (hhp > 0.13)	WEF = -0.85 x ln(hhp) + 2.87

High-Efficiency Condition

The high-efficiency condition is a 1 to 5 hp variable speed pump (VSP) or multi-speed pool pump that is compliant with the ENERGY STAR Final Version 3.1 Requirements for pool pumps effective July 19, 2021.[535] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Additional optional efficiency standards are available, aligning with recommendations from the Consortium for Energy Efficiency (CEE) residential swimming pool pump specification, effective October 21, 2020.[536] For all in-ground pumps, CEE Tier 1 matches the current federal standard, and CEE Tier 2 matches the current ENERGY STAR specification for in-ground standard size pumps. Additional savings are only specified for CEE tiers where there is an incremental efficiency improvement above the ENERGY STAR specification.

Compliance only needs to be verified against the CEE specification when claiming CEE savings that exceed the corresponding ENERGY STAR savings values. ENERGY STAR savings should be claimed for all pumps where CEE compliance is not verified and where there are no CEE savings specified.

[534] Federal standard for dedicated-purpose pool pumps. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=67.

[535] ENERGY STAR Pool Pumps Final Version 3.1 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification_0.pdf.

[536] CEE Residential Swimming Pool Pump Specification. https://library.cee1.org/system/files/library/14404/CEE_ResSwimmingPoolPump_Specification_21Oct2020.pdf.

Table 406. ~~ENERGY STAR~~ Pool Pumps ~~– –Energy Efficiency Level~~High Efficiency Condition

Pump Subtype	Size class	ENERGY STAR	CEE Tier 1	CEE Tier 2
Self-priming (inground) pool pumps	Extra small (hhp ≤ 0.13)	WEF ≥ 13.40	–	–
	Small (hhp > 0.13 to < 0.711)	WEF ≥ -2.45 x ln(hhp) + 8.40	WEF ≥ -1.30 x ln(hhp) + 4.95	WEF ≥ -2.83 x ln(hhp) + 8.84
	Standard (hhp ≥ 0.711)		WEF ≥ -2.30 x ln(hhp) + 6.59	WEF ≥ -2.45 x ln(hhp) + 8.40
Non-self-priming (above ground) pool pumps	Extra small (hhp ≤ 0.13)	WEF ≥ 4.92	–	–
	Standard size (hhp > 0.13)	WEF ≥ -1.00 x ln(hhp) + 3.85	WEF ≥ -1.60 x ln(hhp) + 9.10	–

Energy and Demand Savings Methodology

Savings for this measure are based on methods and input assumptions from the ENERGY STAR Pool Pump Savings Calculator.

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR Pool Pump Savings Calculator with Texas selected as the applicable location, so Texas-specific assumptions were used.[537]

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

Equation 158

Where:

kWh_{base} = *Baseline pool pump energy (kWh)*

kWh_{ES} = *ENERGY STAR variable speed pool pump energy (kWh)*

Algorithms to calculate the above parameters are defined as:

$$kWh_{base} = \frac{PFR_{base} \times 60 \times hours \times days}{WEF_{base} \times 1{,}000}$$

Equation 159

$$kWh_{ES} = \frac{V \times TO \times days}{WEF_{ES} \times 1{,}000}$$

Equation 160

Where:

PFR_{base} = *Baseline pump flow rate [gal/min] (Table 407)*

$_{W}EF_{base}$ = *Baseline pump energy factor [gal/W x hr] (Table 407)*

WEF_{ES} = *ENERGY STAR pump energy factor [gal/W x hr] (Table 408)*

hours = *Pump daily operating hours (Table 407)*

days = *Operating days per year = 365 days (default)*

[537] The ENERGY STAR Pool Pump Savings Calculator, updated February 2013, can be found on the ENERGY STAR website at: https://www.energystar.gov/productfinder/product/certified-pool-pumps/results.

V	=	*Pool volume [gal] (Table 407)*
TO	=	*Turnovers per day, number of times the volume of the pool is run through the pump per day (Table 408)*
60	=	*Constant to convert between minutes and hours*
1,000	=	*Constant to convert from W to kW*

Table 407. Pool Pumps—Baseline Assumptions[538]

New pump HP	Reference HP	Reference HHP[539]	Hours[540]	PFR_{base} (gal/min)
≤ 1.25	1.0	0.533	4.9	75.5000
1.25 < hp ≤ 1.75	1.5	0.800	4.7	78.1429
1.75 < hp ≤ 2.25	2.0	1.066	4.1	88.6667
2.25 < hp ≤ 2.75	2.5	1.333	4.0	93.0910
2.75 < hp ≤ 5	3.0	1.599	4.0	101.6667

Table 408. Pool Pumps—ENERGY STAR Assumptions[541]

New pump HP	V (gal)	Turnovers/day
≤ 1.25	22,000	1.0
1.25 < hp ≤ 1.75		
1.75 < hp ≤ 2.25		
2.25 < hp ≤ 2.75		
2.75 < hp ≤ 5		

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{base} - kWh_{ES}}{hours} \times \frac{CF_{S/W}}{days}$$

Equation 161

[538] Conventional pump PFR and EF values are taken from pump curves found in the ENERGY STAR Pool Pump Savings Calculator. Note: input assumptions will be updated once calculator has been updated for compliance with the current specification.

[539] Hhp not available in ENERGY STAR calculator. Assumed hhp calculated as follows: Ref. horsepower x AF. AF = 0.533 based on ratio of hhp to hp from ENERGY STAR qualified product listing. Accessed 8/11/2023.

[540] The daily average operating hours for conventional single-speed pumps, based on 2014 residential pool pump program survey results from CenterPoint Energy.

[541] ENERGY STAR values are taken from default inputs and pump curves found in the ENERGY STAR Pool Pump Savings Calculator. Note: input assumptions will be updated once calculator has been updated for compliance with the current specification.

Where:

$CF_{S/W}$ = *Seasonal peak coincidence factor (Table 409)*

Table 409. Pool Pumps—Coincidence Factors[542]

Climate zone	Summer CF	Winter CF
Zone 1: Amarillo	0.258	-0.002
Zone 2: Dallas	0.329	0.025
Zone 3: Houston	0.276	0.108
Zone 4: Corpus Christi	0.266	0.036
Zone 5: El Paso	0.497	-0.143

Deemed Energy Savings Tables

Table 410. Pool Pumps—Energy Savings (kWh)[543]

New pump hp	Inground	Above ground
ENERGY STAR		
≤ 1.25	1,371	587
1.25 < hp ≤ 1.75	235	657
1.75 < hp ≤ 2.25	262	707
2.25 < hp ≤ 2.75	332	852
2.75 < hp ≤ 5	509	1,229
CEE Tier 1		
≤ 1.25	–	1,585
1.25 < hp ≤ 1.75	–	1,779
1.75 < hp ≤ 2.25	–	1,935
2.25 < hp ≤ 2.75	–	2,176
2.75 < hp ≤ 5	–	2,642
CEE Tier 2		
≤ 1.25	1,423	–
1.25 < hp ≤ 5	–	–

[542] Coincidence factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from the US Department of Energy's Building America B10 Benchmark load profiles for pool pumps. The profile used to determine coincidence factors is calculated as the difference of single speed and variable speed profiles. Summer profiles include April through September and winter profiles include October through March.

[543] The results in this table may vary slightly from results produced by the ENERGY STAR calculator because of rounding of default savings coefficients throughout the measure and pool volume.

Deemed Summer Demand Savings Tables[544]

Table 411. Pool Pumps—Summer Peak Demand Savings (kW) for Inground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	0.198	0.252	0.212	0.204	0.381
1.25 < hp ≤ 1.75	0.035	0.045	0.038	0.036	0.068
1.75 < hp ≤ 2.25	0.045	0.057	0.048	0.046	0.087
2.25 < hp ≤ 2.75	0.059	0.075	0.063	0.060	0.113
2.75 < hp ≤ 5	0.090	0.115	0.096	0.093	0.173
CEE Tier 1					
All sizes	–	–	–	–	–
CEE Tier 2					
≤ 1.25	0.206	0.262	0.220	0.212	0.396
1.25 < hp ≤ 5	–	–	–	–	–

Table 412. Pool Pumps—Summer Peak Demand Savings (kW) for Above Ground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	0.085	0.108	0.091	0.087	0.163
1.25 < hp ≤ 1.75	0.099	0.126	0.106	0.102	0.190
1.75 < hp ≤ 2.25	0.122	0.155	0.130	0.126	0.235
2.25 < hp ≤ 2.75	0.151	0.192	0.161	0.155	0.290
2.75 < hp ≤ 5	0.218	0.277	0.233	0.224	0.418
CEE Tier 1					
≤ 1.25	0.229	0.291	0.245	0.236	0.441
1.25 < hp ≤ 1.75	0.268	0.341	0.287	0.276	0.516
1.75 < hp ≤ 2.25	0.334	0.425	0.357	0.344	0.643
2.25 < hp ≤ 2.75	0.385	0.490	0.412	0.396	0.741
2.75 < hp ≤ 5	0.468	0.595	0.500	0.481	0.900

[544] Ibid.

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
CEE Tier 2					
All sizes	–	–	–	–	–

Deemed Winter Demand Savings Tables

Table 413. Pool Pumps—Winter Peak Demand Savings (kW) for Inground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	-0.001	0.019	0.083	0.027	-0.110
1.25 < hp ≤ 1.75	0.000	0.003	0.015	0.005	-0.020
1.75 < hp ≤ 2.25	0.000	0.004	0.019	0.006	-0.025
2.25 < hp ≤ 2.75	0.000	0.006	0.025	0.008	-0.032
2.75 < hp ≤ 5	-0.001	0.009	0.038	0.012	-0.050
CEE Tier 1					
All sizes	–	–	–	–	–
CEE Tier 2					
≤ 1.25	-0.001	0.020	0.086	0.029	-0.114
1.25 < hp ≤ 5	–	–	–	–	–

Table 414. Pool Pumps—Peak Demand Savings (kW) for Above Ground Pools

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
ENERGY STAR					
≤ 1.25	-0.001	0.008	0.036	0.012	-0.047
1.25 < hp ≤ 1.75	-0.001	0.010	0.042	0.014	-0.055
1.75 < hp ≤ 2.25	-0.001	0.012	0.051	0.017	-0.067
2.25 < hp ≤ 2.75	-0.001	0.014	0.063	0.021	-0.083
2.75 < hp ≤ 5	-0.001	0.021	0.091	0.030	-0.120

New pump HP	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
CEE Tier 1					
≤ 1.25	-0.001	0.022	0.096	0.032	-0.127
1.25 < hp ≤ 1.75	-0.002	0.026	0.112	0.037	-0.148
1.75 < hp ≤ 2.25	-0.002	0.032	0.140	0.046	-0.185
2.25 < hp ≤ 2.75	-0.002	0.037	0.162	0.053	-0.213
2.75 < hp ≤ 5	-0.003	0.045	0.196	0.065	-0.259
CEE Tier 2					
All sizes	–	–	–	–	–

Claimed Peak Demand Savings

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

Additional Calculators and Tools

ENERGY STAR Pool Pump Savings Calculator, updated May 2020, can be found on the ENERGY STAR website at https://www.energystar.gov/productfinder/product/certified-pool-pumps/results.

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 OutD-PoolPump.[545]

Program Tracking Data and Evaluation Requirements

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

For all projects collect:

- Climate zone or county
- Unit quantity
- Manufacturer and model number of new pool pump
- ENERGY STAR certificate matching model number
- Weighted energy factor of new pool pump
- Rated hydraulic horsepower of new pool pump

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

- Rated horsepower of new pool pump
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or other pre-approved method of installation verification

For a significant sample of projects where attainable (e.g., those projects that are selected for inspection, not midstream or retail programs):

- Items listed for all projects above
- Decision/action type: early retirement, replace-on-burnout, or new construction
- Rated horsepower of existing pool pump
- Existing and new pool pump operating hours

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 415. Pool Pumps—Revision History

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 origin.
v6.0	11/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. Updated eligibility to include above ground pool pumps now eligible for ENERGY STAR certification. Acknowledged the forthcoming ENERGY STAR v2.0.
v8.0	10/2020	TRM v8.0 update. Incorporated ENERGY STAR v2.0 updated deemed savings.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference and documentation requirements.
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Final Version 3.1 Requirements. Updated savings coefficient definitions.
v11.0	10/2023	TRM v11.0 update. Updated baseline to current federal standard. Added new savings tiers. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. No revision.

2.5.13 Advanced Power Strips Measure Overview

TRM Measure ID: R-AP-PS

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings values

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the installation of a multi-plug advanced power strip (APS) with the ability to automatically disconnect specific loads depending on the power draw of a specified, or "master," load.

For a Tier 1 APS, a load sensor in the strip disconnects power from the control outlets when the master power draw is below a certain threshold. This feature allows for a reduction of power draw from peripheral consumer electronics, which usually maintain some load even when in the off or standby position. Therefore, when the master device (e.g., television) is turned off, the power supply is cut to other related equipment (e.g., set-top boxes, speakers, video game consoles).

A Tier 2 APS uses an external sensor paired with a configurable countdown timer to manage both active and standby power loads for controlled devices in a complete system. A Tier 2 APS may operate either with or without a master control socket. Those without a master control socket sense power of all devices connected to the controlled sockets, while those with a master control socket sense power for the device connected to the master control socket. The external sensor of a Tier 2 APS may use an infrared-only sensor, or it may use a "multi-sensor," which detects both infrared (IR) remote control signals and motion to determine device inactivity and deliver additional savings as compared to a Tier 1 APS. Both versions of external sensors use IR filtering to prevent inappropriate switching events that may have otherwise resulted from natural interference, such as sunlight or CFL light bulbs.

Eligibility Criteria

This measure applies to all residential applications. For Tier 2 applications, the APS must control at least two audiovisual devices.

Baseline Condition

The baseline condition is assumed to be uncontrolled peripheral loads, each plugged into a traditional surge protector or wall outlet.

High-Efficiency Condition

The high-efficiency condition is peripheral loads controlled by a Tier 1 or Tier 2 APS.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Savings were developed based on reported plug load electricity consumption and hourly use data. A set of home entertainment and home office peripheral equipment and related performance data are presented in the following table. “Daily Standby Hours” and “Daily Off Hours” represent the average number of hours the device is left in standby or off mode. For each device, a weighted watt per hour value is calculated based on projected watts consumed in either mode.

There are ~~three~~two savings paths available for Tier 1. Savings can be estimated by:

1. Per system type (home entertainment or home office)
2. Per APS for an average complete system if the type is unknown
3. ~~Per individual peripheral device~~

Tier 2 savings are determined using the average component uses for a complete system and an energy reduction percentage.

Table 416. APS—Peripheral Watt Consumption Breakdown[546]

System type	Peripheral device	Daily standby hours	Daily off hours	Standby power (W)	Off power (W)	Weighted W/hr	Annual APS hours
Home entertainment	Audio equipment: AV receiver	0.0	18.0	19.2	3.1	3.1	6,570
	Audio equipment: Speakers	0.0	18.0	3.0	0.0	0.0	6,570
	Audio equipment: Subwoofer	0.0	18.0	7.8	0.6	0.6	6,570
	Media player: Blu-ray	2.5	20.8	7.0	0.1	0.8	8,505
	Media player: DVD	2.5	20.8	5.0	2.0	2.3	8,505
	Media player: DVD-R	2.5	20.8	7.0	3.0	3.4	8,505
	Media player: DVD/VCR	2.5	20.4	8.0	4.0	4.4	8,359
	Media player: VCR	2.2	21.4	6.0	3.0	3.3	8,614
	Set-top box: Cable	0.0	16.5	25.0	16.0	16.0	6,023
	Set-top box: Cable with DVR	0.0	16.5	45.0	43.0	43.0	6,023
	Set-top box: Satellite	0.0	15.1	10.0	15.0	15.0	5,512
	Set-top box: Satellite with DVR	0.0	15.1	27.0	28.0	28.0	5,512
	Set-top box: Stand-alone DVR	0.0	18.3	27.0	27.0	27.0	6,680
	Television: CRT	0.0	18.7	5.3	1.6	1.6	6,826
	Television: LCD	0.0	18.7	2.2	0.5	0.5	6,826
	Television: Plasma	0.0	18.7	0.9	0.6	0.6	6,826
	Television: Projection	0.0	18.7	4.4	7.0	7.0	6,826
	Video game console: Nintendo Wii	1.5	21.4	10.5	1.9	2.5	8,359
	Video game console: Wii U	1.5	21.4	34.0	0.4	2.6	8,359
	Video game console: PlayStation 2	1.5	21.4	17.0	0.2	1.3	8,359

[546] Derived from New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report." August 2011.

System type	Peripheral device	Daily standby hours	Daily off hours	Standby power (W)	Off power (W)	Weighted W/hr	Annual APS hours
Home entertainment	Video game console: PlayStation 3	1.5	21.4	152.9	1.1	11.0	8,359
	Video game console: PlayStation 4	1.5	21.4	137.0	6.4	14.9	8,359
	Video game console: XBOX	1.5	21.4	68.0	2.0	6.3	8,359
	Video game console: XBOX 360	1.5	21.4	117.5	3.1	10.6	8,359
	Video game console: XBOX One	1.5	21.4	112.0	11.9	18.4	8,359
Home office	Computer: Desktop	4.1	16.7	11.6	3.3	4.9	7,592
	Computer: Laptop	4.1	16.7	7.6	4.4	5.0	7,592
	Computer monitor: CRT	2.4	16.5	7.6	1.5	2.3	6,899
	Computer monitor: LCD	2.4	16.5	1.9	1.1	1.2	6,899
	Computer speakers	0.0	18.7	3.7	2.3	2.3	6,826
	Copier	0.0	23.5	2.8	1.5	1.5	8,578
	Fax machine: Inkjet	0.5	23.3	6.0	5.3	5.3	8,687
	Fax machine: Laser	0.5	23.3	5.3	2.2	2.3	8,687
	Printer: Inkjet	4.4	19.5	2.5	1.3	1.5	8,724
	Printer: Laser	4.4	19.5	9.0	3.3	4.3	8,724
	Scanner	0.0	23.5	3.6	2.1	2.1	8,578

Energy Savings Algorithms

Tier 1 APS

Energy savings for a Tier 1 APS in use for home entertainment or home office are calculated using the following algorithm, where kWh saved is calculated and summed for all peripheral devices.

$$Energy\ Savings\ [\Delta kWh] = \sum \frac{W_i \times H_i}{1{,}000} \times ISR$$

Equation 162

Where:

W	=	*Weighted watts per hour consumed in standby/off mode for each peripheral device (see* Table 416*)*
H	=	*Annual hours per year controlled by APS (see Table 416)*
1,000	=	*Constant to convert from W to kW*
ISR	=	*In-service rate or the percentage of units rebated that are installed, see Table 417*

Tier 2 APS

Energy savings for a Tier 2 APS are calculated using the average household home entertainment and home office usages, multiplied by an assumed energy reduction percentage.

$$\Delta kWh_{Home\ Entertainment} = kWh_{TV} \times ERP \times ISR$$

Equation 163

$$\Delta kWh_{Home\ Office} = kWh_{Comp} \times ERP \times ISR$$

Equation 164

$$\Delta kWh_{Unspecified} = \frac{kWh_{TV} + kWh_{Comp}}{2} \times ERP \times ISR$$

Equation 165

Where:

kWh_{TV}	=	*Average annual energy consumption of Tier 2 qualifying TV systems; default = 602.8 kWh*[547]

[547] New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report". August 2011. Page 30.

kWh_{Comp} = *Average annual energy consumption of Tier 2 qualifying computer systems; default = 197.9 kWh*[548]

ERP = *Energy reduction percentage (default = 47.5%*[549]*)*

Table 417. APS—In-Service Rates by Program Type

Program type	ISR
All[550]	0.83

Demand Savings Algorithms

Tier 1 and Tier 2 APS

Demand savings for a Tier 1 APS in use for a home entertainment system or home office are calculated using the following algorithm, where kWh saved is calculated and summed for all peripheral devices. Demand savings for a Tier 2 APS are calculated using the average household home office and home entertainment center usages, multiplied by an assumed energy reduction percentage.

$$Peak\ Demand\ Savings\ [\Delta kW] = \sum \frac{\Delta kWh}{hours} \times CF_{S/W}$$

Equation 166

Where:

hours = *Annual hours per year controlled by APS (see Table 416 for Tier 1 APS; assume 4,380 for Tier 2 APS*[551]*)*

$CF_{S/W}$ = *Seasonal peak coincidence factor (see Table 418)*[552]

Table 418. APS—Coincidence Factors[553]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.33	0.43	0.36	0.30	0.66
Winter	0.89	0.88	0.86	0.85	0.87

[548] New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report". August 2011. Page 30.
[549] Average of ERP from Northeast Energy Efficiency Partnerships (NEEP), "Case Study: Tier 2 Advanced Power Strips and Efficiency Programs". April 2015.
[550] MidAmerican Energy Company & Tetra Tech "Residential Assessment Impact and Process Evaluation FINAL". December 22, 2020, APPENDIX B: IN-SERVICE RATES ANALYSIS, p. 47.
[551] Estimated based on assumption that approximately half of savings are during active hours (assumed to be 5.3 hours/day, or 1,936 hours/year) and half during standby hours (8,760-1,936 = 6,824 hours/year). The resulting weighted average is 4,380 hours/year.
[552] Derived using Electric Power Research Institute (EPRI) End Use Load Shapes for Residential TV and PC. http://loadshape.epri.com/enduse.
[553] See Volume 1, Section 4.

Deemed Energy Savings Tables

Refer to Table 419 and Table 420. The savings presented in these tables must be adjusted by applying the program-specific ISR values specified in Table 417.

Deemed Summer Demand Savings Tables

Refer to Table 419 and Table 420. The savings presented in these tables must be adjusted by applying the program-specific ISR values specified in Table 417Table 18.

Deemed Winter Demand Savings Tables

Refer to Table 419 and Table 420. The savings presented in these tables must be adjusted by applying the program-specific ISR values specified in Table 417.

Table 419. APS—Tier 1 Unadjusted Savings Before Applying ISR[554]

System type	kWh savings	Summer kW savings					Winter kW savings				
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home entertainment[555]	269.9	0.0132	0.0174	0.0143	0.0119	0.0265	0.0358	0.0354	0.0345	0.0342	0.0348
Home office[556]	87.1	0.0037	0.0049	0.0041	0.0034	0.0075	0.0101	0.0100	0.0098	0.0097	0.0098
Upstream/midstream[557]	178.5	0.0084	0.0112	0.0092	0.0077	0.0170	0.0230	0.0227	0.0221	0.0219	0.0223

Table 420. APS—Tier 2 Unadjusted Savings Before Applying ISR[558]

System type	kWh savings	Summer kW savings					Winter kW savings				
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Home entertainment	286.3	0.021	0.028	0.023	0.019	0.043	0.058	0.058	0.056	0.056	0.057
Home office	94.0	0.007	0.009	0.008	0.006	0.014	0.019	0.019	0.018	0.018	0.019
Upstream/midstream	190.2	0.014	0.019	0.015	0.013	0.029	0.039	0.038	0.037	0.037	0.038

[554] Apply in-service rate to adjust savings for specific program delivery type.
[555] Assuming audio equipment: AV receiver, media player: average, set-top box: average, and video game console: average.
[556] Assuming computer: desktop, computer monitor: LCD, computer speakers, and printer: average.
[557] Average of *home entertainment* and *home office system* averages.
[558] Apply in-service rate to adjust savings for specific program delivery type.

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years for a Tier 1 APS, according to the 2011 NYSERDA Advanced Power Strip Research Report.[559] While Tier 2 APS is not covered by the NYSERDA report, assume the same 10-year EUL for Tier 2 APS.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Unit quantity
- Manufacturer and model number
- APS type (Tier 1 or Tier 2)
- System type (home entertainment, home office, unspecified)
- Proof of purchase – including date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification.

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.

[559] New York State Energy Research and Development Authority (NYSERDA), "Advanced Power Strip Research Report". August 2011. Page 30.

Document Revision History

Table 421. APS—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. No revision.
v9.0	10/2021	TRM v9.0 update. Updated savings with current coincidence factors.
v10.0	10/2022	TRM v10.0 update. Corrected typos in deemed savings tables from TRM v9.0 update.
v11.0	10/2023	TRM v11.0 update. Added in-service rates.
v12.0	10/2024	TRM v12.0 update. No revision.

2.5.14 ENERGY STAR® Electric Vehicle Supply Equipment

TRM Measure ID: R-AP-EV

Market Sector: Residential

Measure Category: Appliance

Applicable Business Types: Single-family, manufactured

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of ENERGY STAR qualified Level 2 electric vehicle supply equipment (EVSE) at a residential site. EVSE is the infrastructure that enables plug-in electric vehicles (PEV) to charge onboard batteries. Level 2 EVSE requires 240-volt electrical service. This measure provides deemed savings for the energy efficiency improvement of an ENERGY STAR EVSE compared to~~over~~ a standard Level 1 ~~or non-ENERGY STAR~~ EVSE.

Eligibility Criteria

Eligible equipment includes an ENERGY STAR qualified Level 2 EVSE installed at a residence. The EVSE may be installed for use on either an all-battery electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV). Multifamily buildings should use the commercial EVSE measure.

Baseline Condition

The baseline condition is assumed to be a blend of 49%[560] ~~a~~ Level 1 EVSEs (ENERGY STAR or non-ENERGY STAR) and 51% Level 2 EVSEs. Energy savings are available for the 49% market share of Level 1 EVSEs. ~~non-ENERGY STAR qualified Level 2 EVSE~~.

[560] Calculated as the number of normal power outlets divided by the total number of sampled EV owners for the home category. "Exploring consumer sentiment on electric-vehicle charging", McKinsey & Company. January 9, 2024. Exhibit 2. https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/exploring-consumer-sentiment-on-electric-vehicle-charging.

High-Efficiency Condition

The high-efficiency EVSE is a Level 2 EVSE compliant with ENERGY STAR Final Version 1.1 specification for eligible EVSE, effective March 31, 2021.[561] Energy efficiency service providers are expected to comply with the latest ENERGY STAR requirements.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Savings for EVSE come from efficiency gains of the ENERGY STAR equipment during operating modes when the vehicle is plugged in ~~but not~~and ~~charging~~ charging. Following a study conducted by Frontier Energy, energy savings are established by estimating annual miles driven, average EV fuel economy, and approximate percent (%) of energy savings ~~because of~~attributed to charging with ENERGY STAR Level 2 EVSE as opposed to Level 1 EVSE.~~and when not plugged in. Deemed savings are calculated according to the following algorithms.~~

Energy Savings Algorithms

Table 422~~Table 1~~ presents the most common registered EVs in Texas and their corresponding fuel economy to establish an average annual energy per individual affected by this measure.

Table 422~~:~~. EV Registration by Model - Fuel Economy for EVs in Texas[562]

Make	Model	% of Market[563]	EPA Fuel Economy [kWh/100mi][564]	Weighted Avg. [kWh/100mi]
Tesla	Model 3	24.6%	25	6.2
Tesla	Model Y	22.5%	27	6.1
Tesla	Model S	6.5%	28	1.8
Tesla	Model X	4.1%	32	1.3
Chevrolet	Bolt EV/EUV	3.3%	29	0.8
Ford	Mustang Mach-E	2.4%	34	1.0
Nissan	Leaf	2.0%	31	0.6
Volkswagen	ID.4	1.3%	31	0.4
Ford	F150 Lightning	1.1%	50	0.5
Multiple	Multiple	32.2%	32[565]	10.3
	Total	**100.0%**	**–**	**29.0**

[561] ENERGY STAR EVSE Final Version 1.1 Program Requirements. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20V1.1%20DC%20EVSE%20Final%20Specification_0.pdf.
[562] EVs in Texas, DFW Clean Cities. https://www.dfwcleancities.org/evsintexas.
[563] All models with less than 1 percent of market share were combined.
[564] U.S. Department of Energy. https://www.fueleconomy.gov/.
[565] Average of EPA fuel economy for models with a higher market share.

$$Annual\ Energy\ Consumption\ [kWh_c] = miles \times WAFE$$

Equation 167

$$Annual\ Energy\ Savings\ [\Delta kWh] = kWh_c \times L2\% \times BAF$$

Equation 168

Where:

miles = *Average distance driven per year in the U.S.[566] [miles] = 13,476*

WAFE = *Weighted Average Fuel Economy [kWh/mi] = 0.290 (see Table 422)*

L2% = *Percent savings achieved by Level 2 EVSE compared to Level 1 EVSE[567] = 10%*

BAF = *Baseline Adjustment Factor [%] = 49% (representation of market charging with Level 1 EVSE)*

Demand Savings Algorithms

Demand (kW) savings are not estimated for this measure.

~~$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh \times HCF \times DCF}{days_c \times hours_{p,c}}$$~~

~~**Equation 161**~~

~~*Where:*~~

~~ΔkWh_{ss} = *Steady state energy savings (Table 402)*~~

~~*HCF* = *Hourly coincidence factor (Table 401)*~~

~~*DCF* = *Daily coincidence factor[568] = 0.88*~~

~~$days_c$ = *Number of charging days = 321*~~

~~$hours_{p,c}$ = *Hours per day vehicle is plugged in and charging = 2.4 hr*[569]

[566] Average Annual Miles per Driver by Age Group, U.S. Department of Transportation Federal Highway Administration. https://www.fhwa.dot.gov/ohim/onh00/bar8.htm.

[567] "Texas Residential R&D Electrical Vehicle Study", Frontier Energy for AEP Texas. March 2024.

~~[568] Idaho National Lab (INL) EV Project, June 2015, "Characterize the Demand and Energy Characteristics of Residential Electric Vehicle Supply Equipment," page 6. Eighty-eight percent of PEV owners charge every day.~~

~~[569] INL, page 5. A vehicle plugged in for 11.7 hours and charging for 2.4 hours leaves 9.3 hours when it is plugged in and not charging.~~

~~Table 401. EVSE—Coincidence Factors[570]~~

~~Climate zone~~	~~Summer~~	~~Winter~~
~~Zone 1: Amarillo~~	~~0.044~~	~~0.058~~
~~Zone 2: Dallas~~	~~0.040~~	~~0.053~~
~~Zone 3: Houston~~	~~0.043~~	~~0.041~~
~~Zone 4: Corpus Christi~~	~~0.042~~	~~0.059~~
~~Zone 5: El Paso~~	~~0.033~~	~~0.085~~

Deemed Energy Savings Tables

Table 423 presents the deemed energy savings per EVSE. ~~Networked chargers refer to EVSE that are connected remotely to a larger network and are part of an infrastructure system of connected chargers.~~

Table 423. EVSE—Energy Savings (kWh)

~~Total~~kWh savings ~~(kWh)~~
1914~~0~~
~~71~~

Deemed Summer and Winter Demand Savings Tables

Not applicable.~~Table 403 presents the deemed summer and winter peak kW savings per EVSE.~~

~~Table 403. EVSE—Summer/Winter Peak Demand Savings (kW)[571]~~

~~Climate Zone~~	~~Summer~~	~~Winter~~
~~Zone 1: Amarillo~~	~~0.0009~~	~~0.0012~~
~~Zone 2: Dallas~~	~~0.0008~~	~~0.0011~~
~~Zone 3: Houston~~	~~0.0009~~	~~0.0008~~
~~Zone 4: Corpus Christi~~	~~0.0009~~	~~0.0012~~
~~Zone 5: El Paso~~	~~0.0007~~	~~0.0017~~

Claimed Peak Demand Savings

~~Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.~~Not applicable.

~~570 Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from 3 studies: CCET Wind Integration in ERCOT, Avista Utilities Semi-Annual Report on Electric Vehicle Supply, and Xcel CO EVCS Pilot.~~

~~571 Demand savings are only presented for steady state charging because those savings are higher than demand for plugged-in standby mode.~~

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for an EVSE is assumed to be 10 years.[572]

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Manufacturer and model number
- ~~EVSE type (networked, non-networked)~~
- ESVE quantity
- ENERGY STAR certificate matching EVSE model number
- Vehicle year, make, and model (if available)
- Estimated number of miles driven per day (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.

Document Revision History

Table 424. EVSE—Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. Updated deemed savings tables
v9.0	10/2021	TRM v9.0 update. Updated documentation requirements.

[572] US Department of Energy Vehicle Technologies Office, November 2015, "Costs Associated with Non-Residential Electric Vehicle Supply Equipment" p. 21. https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 update. Verified compliance with ENERGY STAR Final Version 1.1 Requirements. Updated savings calculation assumptions, deemed savings, and documentation requirements.
v11.0	10/2023	TRM v11.0 update. Updated algorithm with days coefficient. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. Updated savings methodology to use a weighted Level 1 and Level 2 baseline.

2.5.15 Induction Cooking

TRM Measure ID: R-AP-IC

Market Sector: Residential

Measure Category: Appliances

Applicable Building Types: Single-family, multifamily, manufactured

Fuels Affected: Electricity

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

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

Residential cooking appliances include ovens, cooktops, and full ranges. A full range consists of an oven with a built-in cooktop. An induction range is an electric oven with a built-in induction cooktop.

Induction technology works on the principle of magnetic induction, where excited eddy currents in ferromagnetic cookware within the presence of an oscillating magnetic field dissipate heat through the Joule effect. This heat is directly generated by the cookware and is transmitted to the food within it, lessening thermal condition heat loss between the heating element and the cookware. Induction cooktops include a switching-power electronics circuit that delivers high-frequency current to a planar coil of wire embedded in the cooking surface. The cookware is magnetically coupled to the coil by the oscillating magnetic field. Current flows in the cooking vessel due to the low resistance of the metal. Resistance is a function of permeability and resistivity of the cookware as well as the frequency of excitation. Typical induction cooktops operate at switching frequency between 25 kHz and 50 kHz, which restricts coupling to ferromagnetic cookware such as cast iron, and some alloys of stainless steel.[573]

According to manufacturers, induction cooktops heat food faster, are easier to clean, are less likely to burn those using them, and have a higher cooking efficiency than electric resistance cooktops.

Eligibility Criteria

This measure requires the installation of an electric range with an induction cooktop or a standalone induction cooktop in a residential application. This measure assumes the use of small cookware typical of residential applications.

[573] Sweeney, M., J. Dols, B. Fortenbery, and F. Sharp (EPRI), "Induction Cooking Technology Design and Assessment." Proceedings of the 2014 ACEEE Summer Study on Energy Efficiency in Buildings, p. 9-370. https://www.aceee.org/files/proceedings/2014/data/papers/9-702.pdf.

Baseline Condition

The baseline condition is defined as an electric range with electric resistance cooktop or a standalone electric resistance cooktop. This measure assumes a default of four burners.

Table 425. Induction Cooking—Baseline Electric Resistance Cooktop Energy Consumption[574]

Number of burners	Electric cooktop baseline kWh
0	84
1	89
2	95
3	101
4	106
5	112
6	118
7+	124

High-Efficiency Condition

The high efficiency condition is defined as an electric range with an induction cooktop or a standalone induction cooktop.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings are calculated as the difference between the baseline and high-efficiency condition unit energy consumption (UEC). These exclude HVAC interactive effects or savings due to reduced kitchen hood consumption. Range oven cooking efficiency varies by cooktop type. Ranges with electric resistance and induction cooktops both have electric resistance oven components. Therefore, baseline and high-efficiency condition oven cooking efficiencies are equivalent and are excluded from the savings calculation.

$$Energy\ Savings\ [\Delta kWh] = UEC_{base} - UEC_{IC}$$

Equation 169

574 "Plug Loads and Lighting Modeling," Codes and Standards Enhancement Initiative (CASE). 2016 California Building Energy Efficiency Standards. June 2016. Table 35. https://www.caetrm.com/media/reference-documents/2016_T24CASE_Report_-_Plug_Load_and_Ltg_Modeling_-_June_2016.pdf.

$$UEC_{IC} = UEC_{base} \times \frac{CE_{base}}{CE_{IC}}$$

Equation 170

Where:

UEC_{base}	=	*Baseline annual unit energy consumption [kWh]; see Table 425*
UEC_{IC}	=	*Induction cooking annual unit energy consumption [kWh]*
CE_{base}	=	*Baseline cooking efficiency = 75 percent*[575]
CE_{IC}	=	*Induction cooking efficiency = 85 percent*[576]

Summer Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{savings}}{8{,}760} \times CF_{S/W}$$

Equation 171

8,760	=	*Total hours per year*
$CF_{S/W}$	=	*Seasonal peak coincidence factor (Table 426)*

Table 426. Induction Cooking—Coincidence Factors[577]

Season	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Summer	0.003	0.003	0.003	0.003	0.002
Winter	0.009	0.008	0.007	0.008	0.010

Deemed Energy Savings Tables

For all applications, this measure assumes a default value of four burners.[578]

[575] "2021-2022 Residential Induction Cooking Tops," ENERGY STAR. https://www.energystar.gov/about/2021_residential_induction_cooking_tops#:~:text=The%20per%20unit%20efficiency%20of,times%20more%20efficient%20than%20gas.

[576] Ibid.

[577] Calculated according to TX TRM Volume 1, Section 4 using data from the US DOE Building America B10 Benchmark load profiles for cooking equipment. Summer profiles include April through September, and winter profiles include October through March. https://www.energy.gov/eere/buildings/building-america-analysis-spreadsheets.

[578] Savings for 0–7+ burners only vary from 10–15 kWh.

Table 427. Induction Cooking—Energy Savings (kWh)

Number of burners	kWh savings
4	12

Deemed Summer Demand Savings Tables

For all applications, this measure assumes a default value of four burners.

Table 428. Induction Cooking—Summer Peak Demand Savings (kW)

Number of burners	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
4	0.000004	0.000004	0.000004	0.000004	0.000003

Deemed Winter Demand Savings Tables

For all applications, this measure assumes a default value of four burners.

Table 429. Induction Cooking—Winter Peak Demand Savings (kW)

Number of burners	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
4	0.000013	0.000011	0.000010	0.000011	0.000014

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of an induction cooktop is 16 years based on the average lifetime specified for electric cooktops in the 2016 DOE life-cycle cost tool for residential cooking products.[579]

[579] US Department of Energy (DOE), Energy Efficiency and Renewable Energy Office (EERE). 2016 SNOPR Analytical Tools: Life-Cycle Cost and Payback Period Analysis Spreadsheet. "Cooking_Pds_LCC_SNOPR_DOE_2016_publication.xlsm." Dockett EERE-2014-BT-STD-0005.

Program Tracking Data and Evaluation Requirements

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

- Climate zone or county
- Decision/action type (new construction, retrofit)
- Baseline unit type (electric range with electric resistance cooktop, standalone electric resistance cooktop)
- New unit type (electric range with induction cooktop, standalone induction cooktop)
- Manufacturer and model number
- Unit quantity
- Burner quantity
- Proof of purchase – with date of purchase and quantity
    - Alternative: photo of unit installed or another pre-approved method of installation verification

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 430. Induction Cooking—Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin.
v11.0	10/2023	TRM v11.0 update. Updated documentation requirements.
v12.0	10/2024	TRM v12.0 update. No revision.

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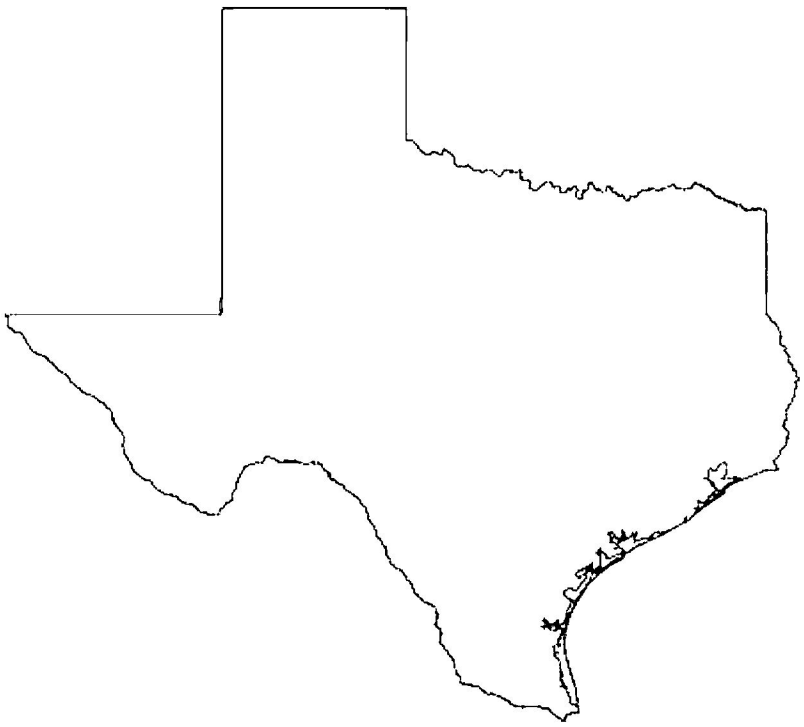

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Acknowledgments

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This version of the Texas Technical Reference Manual was primarily developed from program documentation and measure savings calculators used by the Texas Electric Utilities and their Energy Efficiency Services Providers (EESPs) to support their energy efficiency efforts, and original source material from petitions filed with the Public Utility Commission of Texas by the utilities, their consultants and EESPs such as Frontier Energy (TXu 1-904-705), ICF, CLEAResult and Resource Innovations. Portions of the Technical Reference Manual are copyrighted 2001-2017 by the Electric Utility Marketing Managers of Texas (EUMMOT), while other portions are copyrighted 2001-2018 by Frontier Energy. Certain technical content and updates were added by the EM&V team to provide further explanation and direction as well as consistent structure and level of information.

TRM Technical Support

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1. INTRODUCTION

This volume of the TRM contains the deemed savings for nonresidential measures that have been approved for use in Texas by the PUCT. This volume includes instructions regarding various savings calculators and reference sources of the information. The TRM serves as a centralized source of deemed savings values; where appropriate, measurement and verification (M&V) methods by measure category are noted for informational purposes only regarding the basis of projected and claimed savings.

Table 1 provides an overview of the nonresidential measures contained within Volume 3 and the types of deemed savings estimates available for each one. There are five types of deemed savings estimates identified:

- Point estimates that provide a single deemed savings value that corresponds to a single measure or type of technology.
- Deemed saving tables that provide energy and peak savings as a function of size, capacity, building type, efficiency level, or other inputs.
- Savings algorithms that require user-defined inputs that must be gathered on-site and the identification of default inputs where primary data could not be collected. In many cases, these algorithms are provided as references to deemed savings tables, point estimates, or calculator explanations.
- Calculators are used by different utilities and implementers to calculate energy savings for different measures. In many cases, there are several different calculators available for a single measure. Sometimes their background calculators are similar, and in other cases, estimates can vary greatly between each calculator.
- M&V methods are also used for some measures to calculate savings in the event that standard equipment is not used, or the specified building types do not apply. For some of these measures, both a simplified M&V approach and a full M&V approach may be allowed by the utility. M&V methods as a source of claimed and projected savings are noted for informational purposes only. Standardized M&V approaches that have been reviewed by the EM&V team are incorporated into Volume 4: Measurement and Verification Protocols of this TRM.

Please consult Volume I: Overview and User Guide, Section 4: Structure and Content, for details on the organization of the measure templates presented in this volume.

Table 1. Nonresidential Deemed Savings by Measure Category

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	12.0 update
Lighting	Lamps and fixtures	–	–	X	X	X	Clarified exterior new construction code zone selection guidance, adjusted new construction savings algorithm, updated "Multiple" control type, adjusted non-operational fixture footnote, in-service rate incorporated into retrofit savings algorithm, clarified building type section guidance, and updated midstream building type weighting assumptions.
	Lighting controls	–	–	X	X	X	Consolidated energy adjustment factor (EAF) and power adjustment factor (PAF) coefficient labels to control adjustment factor (CAF).
	Exterior photocell and time clock repair	–	–	X	X	X	No revision.
	LED traffic signals	–	–	X	X	X	No revision.
HVAC	Air conditioning and heat pump tune-ups	–	–	X	–	X	Updated tune-up checklist to match ENERGY STAR HVAC Maintenance Checklist.
	Split and packaged air conditioners and heat pumps	–	–	X	X	X	Updated midstream building type weighting assumptions, defined grade levels for primary and secondary schools, updated early retirement age eligibility and criteria related to downsizing, and noted new federal standard and compliance date
	HVAC chillers	–	–	X	X	X	Updated early retirement age eligibility and criteria related to downsizing, updated midstream building type weighting assumptions, and provided guidance for building types.
	Package terminal air conditioners/heat pumps, and room air conditioners	–	–	X	X	X	Updated early retirement age eligibility and criteria related to downsizing and updated midstream building type weighting assumptions.
	Computer room air conditioners	–	–	X	X	–	Added early retirement criteria related to downsizing, updated early retirement and new construction/replace-on-burnout (ROB) baseline efficiency levels.

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	12.0 update
	Computer room air handler motor efficiency	–	–	X	X	–	No revision.
	HVAC variable frequency drives	–	X	X	–	–	Savings calculations moved to Excel. Reviewed hours of operations for fans and pumps and using same fan and pump hours referenced in the existing measure.
	Condenser air evaporative pre-cooling	–	–	X	–	X	Minor text edits.
	High-volume low-speed fans	–	–	X	–	–	Expanded measure to apply to non-agricultural end uses. Incorporated new efficiency metric for large-diameter fans.
	Small commercial evaporative cooling	–	X	X	–	–	No revision.
	Small commercial smart thermostats	–	–	X	X	X	Minor footnote correction.
Building envelope	Cool roofs	X	–	X	X	–	No revision.
	Window treatments	X	–	X	X	–	Updated measure to indicate solar screen must be permanent, fixed and interior or exterior.
	Entrance and exit door air infiltration	–	X	X	–	–	Adjusted savings normalization from per linear foot to per standard door. Updated documentation requirements.
Food service	ENERGY STAR® combination ovens	–	X	X	–	–	Specified reduced operating schedule for education applications. Aligned deemed savings tables and calculations input assumptions to ENERGY STAR March 2024 update.
	ENERGY STAR® electric convection ovens	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables.
	ENERGY STAR® electric deck ovens	–	X	X	–	–	TRM v12.0 origin.

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	12.0 update
	ENERGY STAR® dishwashers	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables. Added guidance for dual sanitizing dishwashers and updated documentation requirements.
	ENERGY STAR® electric griddles	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables. Updated griddle size to specify a range of griddle sizes based on normal rounding convention. Other minor text updates.
	ENERGY STAR® electric fryers	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables.
	ENERGY STAR® electric steam cookers	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables.
	Contact conveyor toasters	–	X	X	–	–	TRM v12.0 origin.
	Radiant conveyor toasters	–	X	X	–	–	TRM v12.0 origin.
	ENERGY STAR® hot food holding cabinets	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables.
	ENERGY STAR® refrigerated chef bases	–	X	X	–	–	TRM v12.0 origin.
	ENERGY STAR® ice makers	–	X	X	–	–	Specified reduced operating schedule for education applications and updated corresponding deemed savings tables.
	ENERGY STAR® induction cooktops	–	X	X	–	–	TRM v12.0 origin.
	Induction soup wells	–	X	X	–	–	TRM v12.0 origin.

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	12.0 update
	Demand controlled kitchen ventilation	–	X	X	–	–	Clarified new construction eligibility, specified reduced operating schedule for education applications, corrected heating interactive effects, updated heating type distribution, and updated corresponding deemed savings tables.
	Pre-rinse spray valves	–	X	X	–	–	Specified reduced operating schedule for education applications.
	Vacuum-sealing and packaging machines	–	X	–	–	–	No revision.
	Hand wrap machines	–	X	–	–	–	TRM v12.0 origin.
Refrigeration	Door heater controls	–	X	X	–	–	No revision.
	ECM evaporator fan motors	–	–	X	–	–	Clarified baseline condition and documentation requirements.
	Electronic defrost controls	–	–	X	–	–	Correct peak factor naming convention.
	Evaporator fan controls	–	–	X	–	–	No revision.
	Night covers for open refrigerated display cases	–	X	X	–	–	No revision.
	Solid and glass door reach-ins	–	–	X	–	–	Minor corrections.
	Strip curtains for walk-in refrigerated storage	–	X	–	–	–	No revision.
	Zero-energy doors for refrigerated cases	–	X	X	–	–	No revision.
	Door gaskets for walk-in and reach-in coolers and freezers	–	X	X	–	–	No revision.
	High speed doors for cold storage	–	X	X	–	–	Updated estimated useful life (EUL) from 5 to 16 years to match recommendations from 2018 Navigant report.

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	12.0 update
Water heating	Heat pump water heaters	–	–	X	–	–	Cleaned up table column labels and equation parameter definitions. Updated building type names to align with TRM Volume 3 naming convention.
	Central domestic hot water controls	–	X	X	–	–	No revision.
	Showerhead temperature sensitive restrictor valves	–	–	X	–	–	No revision.
	Tub spout and showerhead temperature sensitive restrictor valves	–	–	X	–	–	No revision.
Miscellaneous	Variable frequency drives for water pumping	–	X	X	–	–	No revision.
	Premium efficiency motors	–	–	X	–	–	Updated early retirement age eligibility.
	Pump-off controllers	–	X	X	–	–	No revision.
	ENERGY STAR® pool pumps	–	X	X	–	–	Updated baseline condition and deemed savings to reflect current federal standard.
	Lodging guest room occupancy sensor controls	–	X	–	–	–	No revision.
	Vending machine controls	–	X	X	–	–	No revision.
	Computer power management	–	X	X	–	–	No revision.
	ENERGY STAR® electric vehicle supply equipment	–	X	X	–	–	No revision.
	Industrial high-frequency battery chargers	–	X	X	–	–	No revision.
	Steam trap repair and replacement	–	X	X	–	–	Building types realigned in tables.

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	12.0 update
	Hydraulic gear lubricants	–	–	X	–	–	No revision.
	Hydraulic oils	–	–	X	–	–	No revision.
	Hand dryers	–	X	X	–	–	Updated building type naming convention. Updated peak demand calculation, savings calculation input assumptions, and deemed savings.
	Laser projectors	–	–	X	–	–	No revision.
	Water Pumps	–	–	X	–	–	TRM v12.0 origin.

2. NONRESIDENTIAL MEASURES

2.1 NONRESIDENTIAL: LIGHTING

2.1.1 Lamps and Fixtures Measure Overview

TRM Measure ID: NR-LT-LF

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All commercial, multifamily common areas

Fuels Affected: Electricity (interactive HVAC effects: electric/gas space heating)

Decision/Action Types: Retrofit, and new construction

Program Delivery Type: Prescriptive, custom, direct install

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Guidance for Combination Lighting Fixture & Controls Projects

For lighting retrofits installed in combination with existing controls or controls upgrades, fixture and controls savings should be allocated as follows:

1) Calculate total savings, adjusting pre and post operating hours and coincidence factors to account for applicable controls.

2) Determine if project is eligible to claim controls savings:

    a. Scenario 1: Retrofit project with no baseline controls

    b. Scenario 2: New construction project with controls other than occupancy sensors

3) If controls savings are eligible, calculate controls savings using 2.1.2 Lighting Controls. Otherwise, set controls savings equal to zero.

4) Deduct controls savings from total savings.

5) Claim controls savings using controls EUL. Claim difference of total savings and controls savings using applicable fixture EUL.

Measure Description

This section provides estimates of the energy and peak savings resulting from the installation of energy efficient lamps and/or ballasts. The installation can be the result of new construction or

the replacement of existing lamps and/or ballasts. This TRM Measure ID covers the following lighting technologies:

- Linear fluorescent T5s; high performance or reduced watt T8s. Linear fluorescent measures may also involve delamping[1] with or without the use of reflectors.
- Fluorescent electrodeless induction lamps and fixtures
- Compact fluorescent lamp (CFL) screw-based lamps and hard-wired pin-based fixtures
- Pulse-start (PSMH) and ceramic metal halide (CMH) lamps; high-intensity discharge (HID) lamps
- Light emitting diode (LED) screw-based lamps; hard-wired LED fixtures.

Energy and demand savings are based on operating hours, coincident-load factors, and changes in pre-existing and post-installation lighting loads, as determined using an approved lighting Standard Fixture Wattage table[2], available for download from the Texas Efficiency website and in the Fixture Codes tab in the latest version of the Lighting Survey Form (LSF). The LSF is one example of a calculator that is used to determine energy and demand savings. Pre- and post-retrofit lighting inventories are entered and used with the pre-loaded stipulated values and algorithms needed to calculate energy and demand savings. Components of the calculator include:

- Instructions and project information.
- Pre- and post-retrofit lighting inventories. A tab for exempt fixtures and a description of the exemptions is also present in the calculator.
- Fixture wattages and descriptions are defined in a Standard Fixture Wattage table.
- Factor tables that contain stipulated operating hours, coincidence factors, interactive HVAC factors, control adjustment factors, and new construction lighting power density (LPD) factors.
- A summary tab displaying the final energy and demand calculations. The data from this tab is entered into the utility program tracking data as the claimed savings values.

Although the generic LSF calculator is publicly available on the Texas Energy Efficiency website, several utilities have their own versions.

Eligibility Criteria

This section describes the system information and certified wattage values that must be used to estimate energy and peak savings from lighting systems installed as part of the Texas utility energy efficiency programs. The fixture codes and the demand values listed in the Table of

[1] Delamping energy savings are eligible if done in conjunction with T-8 lamp and electronic ballast retrofits.

[2] Maintained by EUMMOT/Frontier Energy: http://texasefficiency.com/index.php/regulatory-filings/lighting.

Standard Fixture Wattages are used to calculate energy and demand savings for lighting efficiency projects.

Existing lighting fixtures must be removed or demolished in place after retrofit to count towards reduced pre-install wattage. Existing lighting fixtures that remain operable after retrofit should be listed in both the pre- and post-retrofit lighting inventory.

In addition, LED and linear fluorescent T8s need to be qualified, as follows:

- High-performance (HP) and reduced-watt (RW) T8 linear fluorescent lamps need to be qualified by the Consortium for Energy Efficiency (CEE). Their respective ballasts need to be qualified by NEMA.[3] See the High-efficiency Condition section for additional details.
- LED lamps and fixtures must have their input power (wattage) and an L70 rated life (hours) verified through some combination of the following references: DesignLights Consortium® (DLC), ENERGY STAR®, or independent lab testing[4] (e.g., LM-79, LM-80, TM-21, ISTMT). Rated life for LED fixtures should be greater than or equal to 50,000 hours, which can be demonstrated by compliance with DLC v3.0 or later[5] or through independent lab testing. Similarly, rated life for integrated LED lamps should be greater than or equal to 10,000 hours, which can be demonstrated by compliance with ENERGY STAR Version 2.1 Specification or later[6] or through independent lab testing for integrated-ballast LED lamps. These values represent the point at which the minimum L70 was raised to levels consistent with current deemed measure life assumptions.
    - DLC- and ENERGY STAR-certified model numbers should closely align with the installed model number. However, small variances are allowed for portions of the model number that may refer to aspects of the fixture that do not affect energy performance (e.g., color temperature, fixture housing). This allowance is provided at the discretion of the state evaluator and reported model numbers should always default to the closest match available.
    - DLC and ENERGY STAR specifications are periodically updated. Projects may report fixture wattage from older versions of product certifications according to the following certification date guidelines if a copy of the original certification is preserved.

[3] While CEE stopped qualifying ballasts in January 2015, the NEMA Premium Electronic Ballast Program has continued to be maintained and is consistent with the prior CEE specifications for high performance lamps and ballasts, tested in accordance with ANSI C82 Standards.

[4] DLC test lab requirements: https://www.designlights.org/solid-state-lighting/qualification-requirements/testing-lab-requirements/.

[5] Equivalent to the L70 rated life requirement for all categories as specified in DesignLights Consortium™ (DLC) Technical Requirements v3.0. https://www.designlights.org/wp-content/uploads/2021/01/DLC_Technical-Requirements-Table_V3-0.pdf.

[6] Equivalent to the rated life requirement for all lamps as specified in the ENERGY STAR Lamps Version 2.1 Specification . https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf.

1. New construction: permit date
2. Small business: date of customer acceptance or project proposal
3. All other: installation date

- DLC currently tracks delisted products. DLC-delisted products are eligible as long as they were rated for compliance with DLC v3.0 or later. ENERGY STAR does not track delisted products. However, any delisted product may be eligible if prior compliance is documented using a downloaded copy of the prior rating certificate.
- If a product is available in various length increments but is DLC-certified for a specific fixture length, the specified DLC power may be converted to a watts-per-square-foot value to be multiplied against the installed fixture length instead of reporting as a non-qualified fixture.
- Field adjustable light output (FALO): If a product is available with field-adjustable light output (or wattage setpoints) that can be adjusted by an installation contractor to utilize some or all LED nodes on the fixture, this will be noted in the Product Capabilities section of the DLC certification. DLC will typically specify the maximum input wattage. These fixtures should be reported based on the following scenarios:
  - If the fixture is installed at a reduced setpoint, it should be reported at the rated wattage for the reduced setpoint~~maximum input wattage~~ in combination with the ~~institutional tuning (IT)~~"None" control code ~~to claim energy savings associated with a central control lighting output based on tuning sensors. This control type is similar because it is not easily adjustable over time~~. Because DLC only reports the maximum wattage, report reduced wattage setpoint as documented in the manufacturer specification sheet.
  - If the fixture is installed with additional controls (e.g., occupancy sensor, daylighting), then it should be reported using the above guidance in combination with the applicable~~at the maximum input wattage in combination with the ITmultiple~~ control code.
  - If the fixture is installed at the maximum setpoint without adjustment, it should be reported at the maximum DLC input wattage ~~with no control code~~.
  - ~~If the fixture is installed with no additional controls and the DLC certificate specifies a lower wattage setpoint, then it should be reported as the lower input wattage with no control code.~~
  - ~~For all cases, p~~Project documentation for FALO should include a screenshot of the DLC certificate and ~~an example~~ photos of the field-adjustable ~~setpoints~~setpoints for a sample of the installed lighting.

- The same guidance applies to FALO fixtures installed in exterior applications, except that the fixture should always be installed in combination with photocell or timeclock controls.

Exempt lighting for new construction. Some types of new construction lighting fixtures are exempt from inclusion in the interior lighting demand savings calculation, but they are still included in the total installed lighting power calculations for a project. Exempt fixtures are those that do not provide general/ambient/area lighting, have separate control devices, and are installed in one of the following applications:[7]

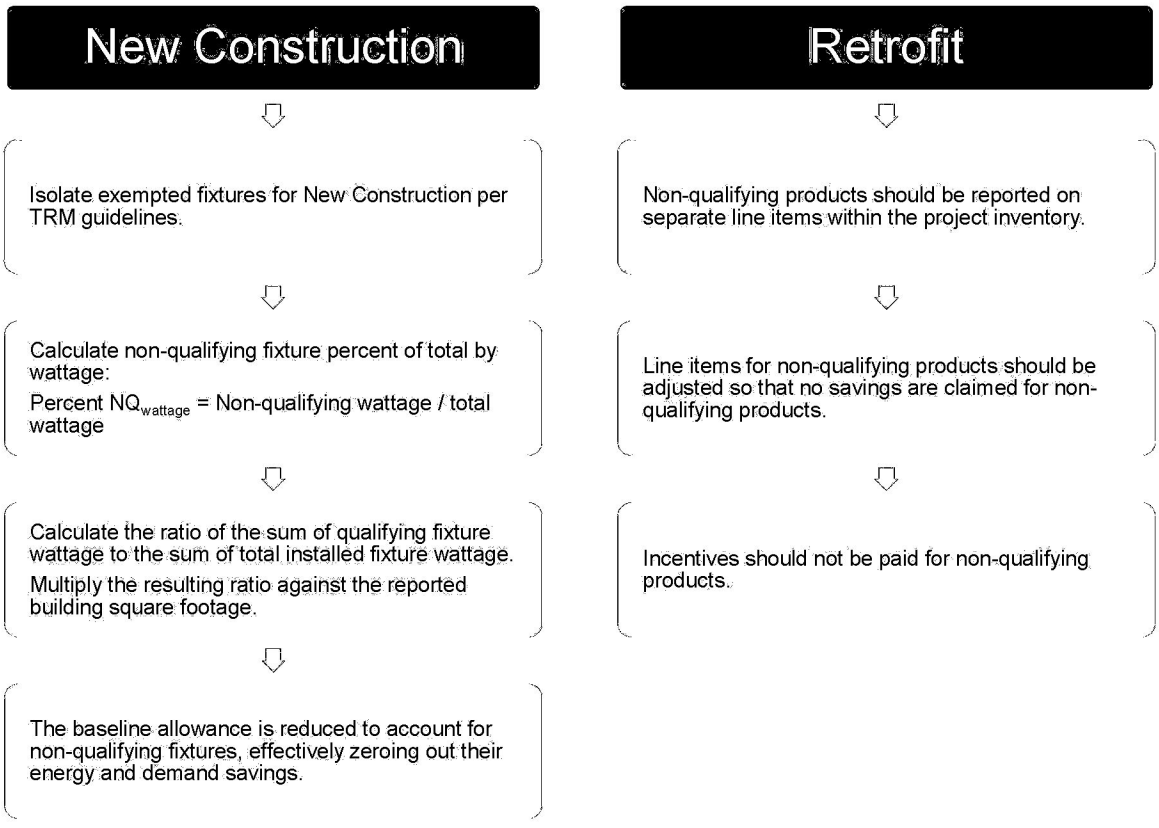
1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power
    1.1. Professional sports arena playing-field lighting
    1.2. Sleeping-unit lighting in hotels, motels, boarding houses, or similar buildings
    1.3. Emergency lighting automatically off during normal building operation
    1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical and age-related issues
    1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark
    1.6. Casino gaming areas
    1.7. Mirror lighting in dressing rooms
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device
    2.1. Task lighting for medical and dental purposes
    2.2. Display lighting for exhibits in galleries, museums, and monuments
3. Lighting for theatrical purposes, including performance, stage, film production, and video production
4. Lighting for photographic processes
5. Lighting integral to equipment or instrumentation and installed by the manufacturer
6. Task lighting for plant growth or maintenance
7. Advertising signage or directional signage
8. In restaurant building and areas, lighting for food warming or integral to food preparation equipment
9. Lighting equipment that is for sale

[7] IECC 2015, Section C405.4.1.

10. Lighting demonstration equipment in education facilities
11. Lighting approved because of safety or emergency considerations, inclusive of exit lights
12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions
14. Furniture-mounted supplemental task lighting that is controlled by automatic shut off
15. Exit signs

Non-Qualifying LEDs. This section provides guidance to assess and calculate nonresidential lighting project savings that include non-qualifying LEDs. Figure 1 summarizes the recommended protocol for lighting system projects with non-qualifying LEDs when square footage cannot be isolated. Additional explanations and criteria for use follow.

Figure 1. Lamps & Fixtures—Non-Qualifying LED Process



Step 1: Qualify New Construction Projects. Calculate non-qualifying LED project percentage:

- Based as a percentage of demand (percent $NQ_{wattage}$ = wattage of non-qualifying fixtures / wattage of total fixtures)

Step 2: New Construction Projects Only. Non-qualifying fixtures that pass Step 1 would follow all instructions for excluded fixtures.

- List non-qualifying LEDs on separate lines (e.g., separate on lighting inventory worksheet of deemed savings calculator). Non-qualifying fixtures are identified by a unique fixture code.
- Adjust code allowable baseline wattage so that non-qualifying fixture wattage is not included as part of the LPD code limit requirements. To do so, calculate the sum of the qualifying fixture wattage and the sum of the total installed fixture wattage. Take the ratio of qualifying fixture wattage to total fixture wattage and multiply the resulting ratio against the total treated square footage for space. The adjusted square footage is included as part of the overall LPD calculation and will decrease the total allowable baseline wattage for the project.
- **Fixture Isolation Method.** If non-qualifying fixtures are isolated to a section of the building whose square footage can be easily segmented from the total building square footage, the non-qualifying fixtures and affected square footage can be excluded from the lighting inventory. Excluded fixtures must be documented when using the fixture isolation method.

Step 3: Retrofit Projects. List non-qualifying LEDs on separate lines (e.g., separate on lighting inventory worksheet of deemed savings calculator).

- Include unique identifiers/markers for the non-qualifying LEDs within the inventory (e.g., fixture code, description, or another designator within the deemed savings tool).
- Adjust non-qualifying LED wattages, so their demand and energy savings are not included as part of the project savings. Demand and energy savings for non-qualifying LEDs shall result in zero-project savings.
- Adjust non-qualifying LED quantities so they are not included as part of the project incentive. Incentives shall not be paid on non-qualifying LEDs.
- Provide clear visibility for all changes within the savings calculation (e.g., deemed savings calculator), including changes to all input assumptions and calculation methodologies to implement the above procedure.
- All other savings procedures and requirements, as specified within the TRM for lighting measures apply to all fixtures of a lighting project.

Baseline Condition

The baseline condition or assumed baseline efficiency used in the savings calculations depends on the decision-type used for the measure. For new construction, the baseline will be based on an LPD in watts per square foot by building/space type, as specified by the relevant energy code/standard applied to a specific project. For *retrofit* applications, the baseline efficiency would typically reflect the in-situ, pre-existing equipment, except for linear fluorescent T12s and first-generation T8s, as explained below. Eligible baseline fixture types and wattages are specified in the Standard Fixture Wattages table.

Major renovation projects should use a new construction baseline (for the building type after the improvement) if either of the following conditions are met:

- Building type changes in combination with the renovation
- Renovation scope includes removing drywall and gutting existing building to the studs

Linear Fluorescent T12 Special Conditions

The US Energy Policy Act of 1992 (EPACT) set energy efficiency standards that preclude certain lamps and ballasts from being manufactured or imported into the US. The latest standards covering general service linear fluorescents went into full effect July 2014. Under this provision, almost all 4-foot and some 8-foot T12 lamps, as well as first-generation 4-foot, 700 series T8 lamps were prohibited from manufacture. Because all lighting equipment for Texas energy efficiency programs must be EPACT compliant, including existing or baseline equipment, adjustments were made to the T12 fixtures in the Standard Fixture Wattage table. Certain T12 lamp/ballast combinations which are non-EPACT compliant are assigned EPACT demand values.

As such, 4-foot and 8-foot T12s are no longer an approved baseline technology for Texas energy efficiency programs. 4-foot and 8-foot T12s are still eligible for lighting retrofit projects, but an assumed electronic T8 baseline will be used for estimating the energy and demand savings instead of the existing T12 equipment. T12 fixtures will remain in the Standard Fixture Wattage table, but the label for these records will be changed to "T12 (T8 baseline)" and the fixture wattage for these records will be adjusted to use the adjusted fixture wattages shown in Figure 2.

Table 2. Lamps & Fixtures—Adjusted Baseline Wattages for T12 Equipment

T12 length	Lamp count	Revised lamp wattage	Revised system wattage
48-inch—std, HO, and VHO (4 feet)	1	32	31
	2	32	58
	3	32	85
	4	32	112
	6	32	170
	8	32	224
96-inch—std (8 feet) 60/75 W	1	59	69
	2	59	110
	3	59	179
	4	59	219
	6	59	330
	8	59	438*
96-inch HO and VHO (8 feet)	1	86	101
	2	86	160

T12 length	Lamp count	Revised lamp wattage	Revised system wattage
95/110 W	3	86	261
	4	86	319
	6	86	481
	8	86	638
2-foot u-tube	1	32	32
	2	32	60
	3	32	89

*8 lamp fixture wattage approximated by doubling 4 lamp fixture wattage.

Key: HO = high output, VHO = very high output.

General Service Lamps

On May 8, 2022, the Department of Energy (DOE) issued two final rules relating to general service lamps (GSL):

- Energy Conservation Program: Definitions for General Service Lamps, effective July 8, 2022, which expanded the definition of a GSL.[8]
- Energy Conservation Program: Energy Conservation Standards for General Service Lamps, effective July 25, 2022, which shifted the baseline to 45 lumens/watt efficacy.[9]

The baseline is assumed to be the second-tier Energy Independence and Security Act of 2007 (EISA)-mandated efficiency for a GSL (see Table 3). The EISA regulations dictate that GSLs must comply with a 45 lumen/watt efficacy standard at time of sale beginning January 1, 2023. ~~However, due to the DOE enforcement schedule, savings may be claimed against the first-tier EISA baseline through February 28, 2023, at the utility's discretion.[10]~~

Table 3. Lamps & Fixtures—EISA 2007 Baseline Adjustment for GSLs [11],[12]

Minimum lumens	Maximum lumens	Incandescent equivalent wattage	2nd Tier EISA 2007 baseline wattage
250	309	25	Exempt

[8] DOE Final Rule: Definitions for General Service Lamps. https://www.regulations.gov/document/EERE-2021-BT-STD-0012-0022.

[9] DOE Final Rule: Energy Conservation Standards for General Service Lamps. https://www.regulations.gov/document/EERE-2021-BT-STD-0005-0070.

~~[10] See PY2022 TRM 9.0 for methodology and baseline.~~

[11] Federal standard for General Service Incandescent Lamps (GSILs): https://www1.eere.energy.gov/buildings/appliance standards/standards.aspx?productid=20.

[12] If exempt, refer to incandescent equivalent wattage.

Minimum lumens	Maximum lumens	Incandescent equivalent wattage	2nd Tier EISA 2007 baseline wattage
310	749	40	12
750	1,049	60	20
1,050	1,489	75	28
1,490	2,600	100	45
2,601	3,300	150	66

High-Efficiency Condition

Eligible efficient fixture types and wattages are specified in the Standard Fixture Wattages table. In addition, some technologies such as LEDs must meet the additional requirements specified under Eligibility Criteria.

High-Efficiency/Performance Linear Fluorescent T8s

All 4-foot T8 post-retrofit technologies and new construction projects must use electronic ballasts manufactured after November 2014,[13] and high-performance T8 lamps that are on the T8 Replacement Lamp products list developed by the Consortium for Energy Efficiency (CEE) as published on its website.

If CEE does not have efficiency guidelines for a T8 system (such as for 8-foot, 3-foot, 2-foot, and U-bend T8 products), the product must have higher light output or reduced wattage than its standard equivalent product (minimum efficacy of 75 mean lumens per watt), while also providing a CRI (color rendering index) greater than 80, and an average rated life of 24,000 hours at three hours per start. In addition, 2-foot and 3-foot ballasts must also use electronic ballasts manufactured after November 2014.

Solar LEDs

Solar-powered LEDs are common in several commercial applications, primarily associated with pole-mounted fixtures. Solar lighting uses photovoltaic (PV) cells, which absorb solar energy to charge a battery and power the fixture. By default, solar fixtures should use an efficient wattage of 0. Because fixture performance relies on battery performance, the measure life for solar fixtures is capped at the expected battery life.

[13] Changes to the DOE Federal standards for electronic ballasts effective November 2014 met both the CEE performance specification and the NEMA Premium requirements, so CEE discontinued their specification and qualifying product lists. A legacy ballast list from January 2015 is still available.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for all lighting projects. Savings are calculated using separate methods for retrofit and new construction projects.

Retrofit[14,15]

$$Energy\ Savings\ [kWh] = \left(kW_{pre} \times Hours_{pre} \times ~~E~~(1 - CAF_{pre}) - kW_{~~postinstalled~~} \times Hours_{postinstalled} \times (1 - CAF_{post})\right) \times IEF_{~~HVAC~~energy} \times ISR$$

Equation 1

$$Peak\ Demand\ Savings\ [kW] = \left(kW_{pre} \times CF_{pre} \times (1 - CAF_{pre}) ~~PCAF_{pre}~~ - kW_{~~postinstalled~~} \times CF_{post~~S/W~~} \times (1 - CAF_{post})\right) \times IEF_{~~HVAC~~demand} \times ISR$$

Equation 2

New Construction

$$Energy\ Savings\ [kWh] = \left(\frac{LPD \times FloorArea}{1{,}000} - kW_{~~postinstalled~~}\right) \times Hours \times (1 - CAF_{post}) \times IEF_{~~HVAC~~energy}$$

Equation 3

$$Peak\ Demand\ Savings\ [kW] = \left(\frac{LPD \times FloorArea}{1{,}000} - kW_{~~postinstalled~~}\right) \times CF_{~~S/W~~} \times (1 - CAF_{post}) \times IEF_{~~HVAC~~demand}$$

Equation 4

Where:

kW_{pre} = *Total kW of existing measure(s) (Approved baseline fixture code*

[14] The number of non-operating fixtures will be limited to 10% of the total fixture count per facility. For projects exceeding this threshold, pre- and post-fixture count should be adjusted by multiplying fixture count against [1 - (% of non-operational fixtures – 0.1)]. No adjustment is applied to projects with less than 10% non-operational fixtures.

[15] The energy and demand savings calculations should also account for lighting controls that are present on existing lighting systems. The ~~E~~CAF ~~and PAF~~ factors in the Lighting Controls measure section should be used for these calculations to adjust the deemed hours and coincidence factors on the pre-side of the equations.

		wattage from deemed savings tool divided by 1,000 and multiplied by fixture/lamp quantity)
$kW_{installed}$	=	*Total kW of retrofit measure(s) (Verified installed fixture code wattage from deemed savings tool divided by 1,000 and multiplied by fixture/lamp quantity)*[16]

Note: wattage for installed LED fixtures may be rounded up or down to the nearest half watt; all other wattages should be rounded to the nearest watt.

LPD	=	*Acceptable lighting power density based on building type from efficiency codes from Table 4 (W/ft2)*
Floor Area	=	*Floor area of the treated space where the lights were installed*
Hours	=	*Hours by building type from Table 9*
~~E~~CAF	=	*~~Energy~~Controls adjustment factor from Lighting Controls measure (set equal to ~~1~~0 if no controls are installed on the existing fixture)*
$CF_{~~SAW~~}$	=	*Summer/winter seasonal peak coincidence factor by building type (see Table 10 or Table 11)*
~~*PAF*~~	~~=~~	~~*Power adjustment factor from Lighting Controls measure (set equal to 1 if no controls are installed on the existing fixture)*~~
IEF_{e}~~*HVAC*~~$_{~~energy~~}$		*= Energy ~~interactive~~ HVAC interactive effects factor by building type (see Table 12)*
IEF_{d}~~*HVAC*~~$_{~~demand~~}$		*= Demand ~~interactive~~ HVAC interactive effects factor by building type (see Table 12)*
ISR	=	*In-service rate, the percentage of incentivized units that are installed and in use (rather than removed, stored, or burnt out) to account for units incentivized but not operating = 1.0 unless otherwise specified for midstream/upstream applications (see Table 13)*

Each of the parameters in these equations, and the approach or their stipulated values, are discussed in detail below.

[16] Installed fixture wattage for fixtures defined by DLC as having "field-adjustable light output capability under the product features tab should be reported at the "default," or maximum lumen output, setting. These fixtures may also utilize the Institutional Tuning control type. Field adjustments should be tracked in project inventories and verified with lumen measurements conducted during field inspections.

Lamp and Fixture Wattages (kW_{pre}, $kW_{installed}$)

Existing construction: standard fixture wattage table.[17] Another example of standard fixture wattage can be found in the Fixture Codes tab of the latest version of the LSF. This table is used to assign identification codes and demand values (watts) to common fixture types (e.g., fluorescent, incandescent, HID, LED) used in commercial applications. The table is subdivided into lamp types (e.g., linear fluorescent, compact fluorescent, mercury vapor) with each subdivision sorted by fixture code. Each record (or row) in the table contains a fixture code, serving as a unique identifier. A legend explains the rules behind the fixture codes.

Each record also includes a description of the fixture, the number of lamps, the number of ballasts if applicable, and the fixture wattage. The table wattage values for each fixture type are averages of various manufacturers' laboratory tests performed to ANSI test standards. By using standardized demand values for each fixture type, the Table simplifies the accounting procedures for lighting equipment retrofits. The table is updated periodically as new fixtures are added.

The fixture codes and the demand values listed in the watt/fixture column in the Table of Standard Fixture Wattages are used to calculate energy and demand savings for any lighting efficiency project.

For implementers interested in adding new fixtures to EUMMOT's lighting table, a request should be submitted to Frontier. The request should include all information required to uniquely identify the fixture type and to fix its demand, as well as other contextual information needed for the table. If possible, the request should also be supported by manufacturer's ANSI test data. Frontier periodically releases updated versions of the LSF with new fixture codes.

New construction: LPD table. For new construction projects, the post-retrofit lighting wattages are determined as they are for the existing construction projects from the Standard Fixture Wattage table. However, the baseline wattage is determined from the treated floor area and an LPD value, which are the allowable watts per square foot of lit floor area as specified by the relevant energy code. The applicable baseline is determined by the energy code that was in effect at the time of building permit issuance. The code selected for energy savings calculations should match the code shown in the permit drawings. The current Commercial energy code for the state of Texas is IECC 2015, but local jurisdictions may have adopted more recent versions.[18] These values for interior space types ~~across~~for IECC 2015~~, IECC 2018, and IECC 2021~~ are presented in Table 4.

In Table 6, the lighting zones used for exterior space types are:

- Zone 1: Developed areas of national parks, state parks, forest lands, and rural areas

[17] Maintained by EUMMOT/Frontier Energy: http://texasefficiency.com/index.php/regulatory-filings/lighting.

[18] Cities Adopted Code List: SPEER. https://eepartnership.org/wp-content/uploads/2023/08/2023-Cities-Adopted-Code-updated-8.21.2023-1.xlsx.

- Zone 2: Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited night-time use, and residential mixed-use areas
- Zone 3: All other areas
- Zone 4: High-activity commercial districts in major metropolitan areas as designated by the local land-use planning authority.

Projects should default to Zone 2. Other zones can be selected with documentation of the adjustment~~In most cases, the Zone 1, 2, or 4 will be selected. Default to Zone 2 if the space type cannot be determined~~. Documentation includes a site aerial with a review of the neighboring properties to validate alternate selection. City zoning drawings ~~can~~ may be used to validate a Zone 4 selection. ~~At a minimum, project documentation should include the rationale for selecting Zone 4. Zone 3 should only be selected if it can be clearly demonstrated that none of the others apply. The reported zone should match the code compliance report (COMcheck), if available.~~

Table 4. Lamps & Fixtures—New Construction LPDs for Interior Space Types by Building Type[19]

Facility type	LPD (W/ft^2)	Facility type	LPD (W/ft^2)
Automotive facility	0.80	Multifamily	0.51
Convention center	1.01	Museum	1.02
Courthouse	1.01	Office	0.82
Dining: bar/lounge/leisure	1.01	Parking garage	0.21
Dining: cafeteria/fast food	0.90	Penitentiary	0.81
Dining: family	0.95	Performing arts	1.39
Dormitory	0.57	Police stations	0.87
Exercise center	0.84	Post office	0.87
Fire station	0.67	Religious buildings	1.00
Gymnasium	0.94	Retail	1.26
Health care/clinic	0.90	School/university	0.87
Hospital	1.05	Sports arena	0.91
Hotel/motel	0.87	Town hall	0.89
Library	1.19	Transportation	0.70
Manufacturing facility	1.17	Warehouse	0.66
Motion picture theater	0.76	Workshop	1.19

[19] IECC 2015 Table C405.4.2(1) and ANSI/ASHRAE/IESNA Standard 90.1-2013 Table 9.5.1.