Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-24-1	R	3/29/2024	1/1/2025	R/MF Refrigerator and Freezer	Updated Measure Description to align with federal standard and ENERGY STAR®; added baseline and compliance case maximum annual energy use tables and default savings; revised occupancy factor language and guidance	Pg. 49
3-24-2	R	3/29/2024	1/1/2025	R/MF Low-Flow – Faucet Aerator	Updated default person/household value for unknown housing type	Pg. 164
3-24-3	R	3/29/2024	1/1/2025	R/MF Low-Flow – Showerhead	Updated default person/household value for unknown housing type	Pg. 172
3-24-4	R	3/29/2024	1/1/2025	R/MF Thermostat – Programmable Setback	Expanded Measure Description to include all non-connected thermostat types; updated value/source for heating ESF; added clarification on derivation of cooling ESF	Pg. 341
3-24-5	R	3/29/2024	1/1/2025	R/MF Connected Lighting	Revised definition to cover connected lighting products including lamps and central hub-controlled systems; updated method to be applied for interior/exterior lighting separately; modified interactive impact and coincidence factors to apply values based on location	Pg. 357
3-24-6	R	3/29/2024	1/1/2025	C/I Oven, Steamer, Fryer, Griddle	General formatting/grammatical corrections; updated default savings table to align with baseline and compliance parameters	Pg. 512
3-24-7	R	3/29/2024	1/1/2025	C/I Compressed Air – Low Pressure Drop Filters	Revised to provide guidance on proper application in multi-compressor/multi-filter systems; updated source for per psid savings	Pg. 602
3-24-8	R	3/29/2024	1/1/2025	C/I Chiller – Air and Water Cooled	General maintenance review; language updated for consistency with other TRM measures	Pg. 717
3-24-9	Removal	3/29/2024	3/29/2024	C/I Chiller – Cooling Tower	No revisions applied – measure marked for removal from TRM	Pg. 721

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-24-10	R	3/29/2024	1/1/2025	C/I Refrigerated Case LED	General maintenance review; updated Measure Description to reflect terminology consistent with other TRM measures; restricted to retrofit scenarios only; updated method to include refrigeration system interactive impacts consistent with other TRM measures; added default baseline wattage values; added hours adjustment for lighting controlled by motion sensors	Pg. 910
3-24-11	R	3/29/2024	1/1/2025	C/I Elevator Drive System Upgrade	Measure name updated from "Elevator Modernization"; Measure Description updated to align with intended scope (drive upgrade); restriction on facility type removed; algorithms consolidated to address all retrofit scenarios; significant overhaul of all sections to align with new approach	Pg. 925
3-24-12	R	3/29/2024	1/1/2025	C/I Variable Frequency Drive (VFD) – Fan and Pump	General maintenance review; CF term removed to reflect that deemed kW savings address system peak coincidence	Pg. 956
3-24-13	R	3/29/2024	1/1/2025	C/I Anti-Condensation Heater Control	General maintenance review; updated Measure Description to reflect terminology consistent with other TRM measures; updated method to include refrigeration system interactive impacts consistent with other TRM measures; updated default heater load guidance; revised CF value and source	Pg. 1054
3-24-14	R	3/29/2024	1/1/2025	C/I Evaporator Fan Control	General maintenance review; updated Measure Description to reflect terminology consistent with other TRM measures; updated method to include refrigeration system interactive impacts consistent with other TRM measures	Pg. 1058
3-24-15	R	3/29/2024	1/1/2025	Appendix J	Removed large C&I deemed savings for economizers	Pg. 1313
3-24-16	R	3/29/2024	1/1/2025	Appendix P	Added GSHP desuperheater EUL aligned with HPWH lifetime; Added 20 year cap for all lighting measure EULs	Pg.1389

Note: Revisions, Additions, Corrections and Removals to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between January 8, 2024 – March 29, 2024.

APPLIANCE

REFRIGERATOR AND FREEZER

Measure Description

This measure covers the replacement of inefficient residential grade refrigerators and freezers with ENERGY STAR® compliant equipment. Residential refrigerators and freezers include electric refrigerators, electric refrigerator-freezers, and freezers, having a source of refrigeration requiring single phase, alternating current electric energy input only. Known collectively as "refrigeration products," these appliances chill and preserve food and beverages, provide ice and chilled water, and freeze food.[1]

This measure is restricted to the purchase of new units only and prohibits application of the prescribed method to products purchased on the secondary market.

This measure does not apply to installation of refrigerators and refrigerator-freezers with a total refrigerated volume exceeding 39 ft^3.[2] LMI baselining provisions included in this measure are restricted to standard size refrigerators/freezers only.

Savings are calculated between the energy consumption of the baseline unit and that of the more efficient replacement meeting ENERGY STAR® minimum performance specification of at least 10% lower energy consumption than that mandated by federal standards.[3]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_{baseline} - kWh_{ee}) \times (1 + HVAC_c) \times F_{occ}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{kWh_{baseline} - kWh_{ee}}{8{,}760}\right) \times (1 + HVAC_d) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times (kWh_{baseline} - kWh_{ee}) \times HVAC_{ff} \times F_{occ}$$

[1] The Retail Products Platform (RPP) Evaluation Report, conducted by EMI Consulting d/b/a Con Edison (approved June 15, 2018), was reviewed for findings relevant to this measure. The findings of this report, which estimates the short-term energy savings and demand reduction attributable to the program's activities and assesses key components of the program's logic model, do not directly inform the algorithms, key inputs or default values found in this energy savings estimation methodology. As such, no changes have been applied as a result of this review.
[2] 10 CFR 430.32(a).
[3] ENERGY STAR® Refrigerators & Freezers Key Product Criteria.

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Characteristic of baseline condition
$_{ee}$	= Characteristic of energy efficient condition
kWh	= Annual electric energy consumption
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_{ff}$	= HVAC interaction factor for annual fossil fuel consumption
F_{occ}	= Adjustment factor to account for number of occupants
CF	= Coincidence factor
8,760	= Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		See Baseline Efficiencies section below for more information.
kWh_{ee}		From application.
F_{occ}		See Occupant Adjustment Factor section below.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. If unknown, assume Single - Family Home building type, New vintage, and AC with Fuel heat HVAC type. See Appendix D.
$HVAC_d$		HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. If unknown, assume Single - Family Home building type, New vintage, and AC with Fuel heat HVAC type. See Appendix D.
$HVAC_{ff}$		HVAC interaction factor for annual fossil fuel energy consumption (MMBtu/kWh). Vintage and HVAC type weighted average by city. If unknown, assume Single - Family Home building type, New vintage, and AC with Fuel heat HVAC type. See Appendix D.
CF	1.0	

Default Values

The table below provides default values for $kWh_{baseline}$ and kWh_{ee} that produce conservative savings for the purposes of developing deemed savings per consumer refrigeration Product Class. These values may be used when program delivery methods preclude the collection of key product specifications needed to establish product-specific baseline and efficient case annual energy consumption values. Default AV values (presented in ft^3) are taken from the Savings Calculator for ENERGY STAR® Qualified Appliances.[4]

[4] Savings Calculator for ENERGY STAR® Qualified Appliances (accessed 01/22/2024)

Product Class	Default AV (ft^3)	$kWh_{baseline}$	kWh_{ee}
Standard Size Models: 7.75 cubic feet or greater			
1. Refrigerator-freezers and refrigerators (other than all-refrigerators) with manual defrost.[5]	12.2	322.48	290.22
1A. All-refrigerators—manual defrost.	12.2	276.44	248.74
2. Refrigerator-freezers—partial automatic defrost	12.2	322.48	290.22
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	17.9	378.15	340.25
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	17.9	428.69	385.90
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	17.9	462.15	424.25
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	17.9	512.69	469.90
3A. All-refrigerators—automatic defrost.	17.9	328.15	295.24
3A-BI. Built-in All-refrigerators—automatic defrost.	17.9	372.06	334.94
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	22.7	490.98	441.88
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	22.7	589.39	530.54
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	22.7	574.98	525.88
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	22.7	673.39	614.54
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	20.0	494.00	444.70
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	20.0	524.90	472.40
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	20.0	578.00	528.70
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	20.0	608.90	556.40
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	25.4	710.35	647.88
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	25.4	749.58	683.09
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	17.9	535.76	490.62
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	24.6	642.88	587.07
7-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	24.6	754.75	687.76
8. Upright freezers with manual defrost	12.6	263.88	237.43

[5] This Product Class represents products defined as "Refrigerator-Freezer" and "Refrigerator" per the Code of Federal Regulations with manual defrost. It explicitly excludes products defined as "All-refrigerator" with manual defrost, which is the scope of Product Class 1A.

Product Class	Default AV (ft^3)	$kWh_{baseline}$	kWh_{ee}
9. Upright freezers with automatic defrost without an automatic icemaker	16.9	373.98	336.64
9I. Upright freezers with automatic defrost with an automatic ice-maker	16.9	457.98	420.64
9–BI. Built-In Upright freezers with automatic defrost without an automatic icemaker	16.9	427.53	384.70
9I–BI. Built-in upright freezers with automatic defrost with an automatic icemaker	16.9	511.53	468.70
10. Chest freezers and all other freezers except compact freezers	15.4	220.07	198.02
10A. Chest freezers with automatic defrost	15.4	305.80	275.29
Compact Size Models: Less than 7.75 cubic feet and 36 inches or less in height			
11. Compact refrigerator-freezers and refrigerators (other than all-refrigerators) with manual defrost.[6]	3.3	282.10	253.93
11A.Compact all-refrigerators—manual defrost.	3.3	244.97	220.50
12. Compact refrigerator-freezers—partial automatic defrost	3.2	354.71	319.22
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	4.5	392.30	353.09
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	4.5	476.30	437.09
13A. Compact all-refrigerators—automatic defrost.	4.5	300.57	270.53
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	4.5	487.59	438.83
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	4.5	571.59	522.83
15. Compact refrigerator-freezers—automatic defrost with bot-tom-mounted freezer.	5.1	399.38	359.46
15I. Compact refrigerator-freezers—automatic defrost with bot-tom-mounted freezer with an automatic icemaker.	5.1	483.38	443.46
16. Compact upright freezers with manual defrost	3.0	251.65	226.47
17. Compact upright freezers with automatic defrost	5.3	405.80	365.20
18. Compact chest freezers	12.4	251.50	226.39

Occupant Adjustment Factor (F_{occ})

The occupant adjustment factor is used to adjust the energy savings according to the number of occupants in the residence (if applicable), as shown in the table below. If unknown, apply a default F_{occ} value of 1.00 as default.

Number of Occupants	F_{occ}[7]
Unknown	1.00
0 occupants	1.00
1 occupant	1.05
2 occupants	1.10
3 occupants	1.13
4 occupants	1.15

[6] This Product Class represents products defined as "Compact Refrigerator-Freezer" and "Compact Refrigerator" per the Code of Federal Regulations with manual defrost. It explicitly excludes products defined as "Compact All-refrigerator" with manual defrost, which is the scope of Product Class 11A.

[7] The Occupant Adjustment Factor is developed from simulating audits within the ORNL weatherization tool, National Energy Audit Tool (NEAT), Oak Ridge National Laboratory, 2012.

Number of Occupants	F_{occ}[7]
5 or more	1.16

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[8]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for market rate applications is a minimally federal standard compliant refrigerator, refrigerator-freezer or freezer as defined in the Measure Description section above. Baseline annual electric consumption (kWh/yr) shall align with federally mandated maximum energy use associated with the Product Class and Adjusted Volume (AV in ft^3 or av in L), calculated in accordance with the Code of Federal Regulations[9], of the qualifying equipment. The table below provides guidance for calculating baseline annual electric consumption ($kWh_{baseline}$) based on Product Class and Adjusted Volume per the Code of Federal Regulations.[10]

Product Class	$kWh_{baseline}$ (AV in ft^3)	$kWh_{baseline}$ (av in L)
Standard Size Models: 7.75 cubic feet or greater		
1. Refrigerator-freezers and refrigerators (other than all-refrigerators) with manual defrost.[11]	7.99AV + 225.0	0.282av + 225.0
1A. All-refrigerators—manual defrost.	6.79AV + 193.6	0.240av + 193.6
2. Refrigerator-freezers—partial automatic defrost	7.99AV + 225.0	0.282av + 225.0
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	8.07AV + 233.7	0.285av + 233.7
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	9.15AV + 264.9	0.323av + 264.9
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	8.07AV + 317.7	0.285av + 317.7
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	9.15AV + 348.9	0.323av + 348.9
3A. All-refrigerators—automatic defrost.	7.07AV + 201.6	0.250av + 201.6
3A-BI. Built-in All-refrigerators—automatic defrost.	8.02AV + 228.5	0.283av + 228.5
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	8.51AV + 297.8	0.301av + 297.8
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	10.22AV + 357.4	0.361av + 357.4
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	8.51AV + 381.8	0.301av + 381.8

[8] *No source specified – update pending availability and review of applicable references.*
[9] 10 CFR 430 Subpart B, Appendices A and B.
[10] 10 CFR 430.32 (a)
[11] This Product Class represents products defined as "Refrigerator-Freezer" and "Refrigerator" per the Code of Federal Regulations with manual defrost. It explicitly excludes products defined as "All-refrigerator" with manual defrost, which is the scope of Product Class 1A.

Product Class	$kWh_{baseline}$ (AV in ft^3)	$kWh_{baseline}$ (av in L)
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	10.22AV + 441.4	0.361av + 441.4
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	8.85AV + 317.0	0.312av + 317.0
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	9.40AV + 336.9	0.332av + 336.9
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	8.85AV + 401.0	0.312av + 401.0
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	9.40AV + 420.9	0.332av + 420.9
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	9.25AV + 475.4	0.327av + 475.4
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	9.83AV + 499.9	0.347av + 499.9
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	8.40AV + 385.4	0.297av + 385.4
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	8.54AV + 432.8	0.302av + 432.8
7-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	10.25AV + 502.6	0.362av + 502.6
8. Upright freezers with manual defrost	5.57AV + 193.7	0.197av + 193.7
9. Upright freezers with automatic defrost without an automatic icemaker	8.62AV + 228.3	0.305av + 228.3
9I. Upright freezers with automatic defrost with an automatic icemaker	8.62AV + 312.3	0.305av + 312.3
9–BI. Built-In Upright freezers with automatic defrost without an automatic icemaker	9.86AV + 260.9	0.348av + 260.9
9I–BI. Built-in upright freezers with automatic defrost with an automatic ice-maker	9.86AV + 344.9	0.348av + 344.9
10. Chest freezers and all other freezers except compact freezers	7.29AV + 107.8	0.257av + 107.8
10A. Chest freezers with automatic defrost	10.24AV + 148.1	0.362av + 148.1
Compact Size Models: Less than 7.75 cubic feet and 36 inches or less in height		
11. Compact refrigerator-freezers and refrigerators (other than all-refrigera-tors) with manual defrost.[12]	9.03AV + 252.3	0.319av + 252.3
11A.Compact all-refrigerators—manual defrost.	7.84AV + 219.1	0.277av + 219.1
12. Compact refrigerator-freezers—partial automatic defrost	5.91AV + 335.8	0.209av + 335.8
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	11.80AV + 339.2	0.417av + 339.2
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	11.80AV + 423.2	0.417av + 423.2
13A. Compact all-refrigerators—automatic defrost.	9.17AV + 259.3	0.324av + 259.3

[12] This Product Class represents products defined as “Compact Refrigerator-Freezer” and “Compact Refrigerator” per the Code of Federal Regulations with manual defrost. It explicitly excludes products defined as “Compact All-refrigerator” with manual defrost, which is the scope of Product Class 11A.

Product Class	$kWh_{baseline}$ (AV in ft^3)	$kWh_{baseline}$ (av in L)
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	6.82AV + 456.9	0.241av + 456.9
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	6.82AV + 540.9	0.241av + 540.9
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	11.80AV + 339.2	0.417av + 339.2
15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker.	11.80AV + 423.2	0.417av + 423.2
16. Compact upright freezers with manual defrost	8.65AV + 225.7	0.306av + 225.7
17. Compact upright freezers with automatic defrost	10.17AV + 351.9	0.359av + 351.9
18. Compact chest freezers	9.25AV + 136.8	0.327av + 136.8

Federal standard annual electric consumption data is provided in the directory of ENERGY STAR® qualified Refrigerators[13] and Freezers[14] according to the make and model of the qualifying equipment. The values specified by ENERGY STAR® incorporate conversion from total capacity to Adjusted Volume as dictated by the Code of Federal Regulations. As an alternative to calculating baseline annual electric consumption for market rate applications per the table above, $kWh_{baseline}$ may be determined from the ENERGY STAR® directory, applying the US Federal Standard (kWh/yr) value located on the ENERGY STAR® Product Finder for the applicable equipment.[15]

The baseline condition for LMI is determined by the LMI Baseline Annual kWh Use in the table below, based on the existing refrigerator or freezer product class, manufacture date and size. The annual baseline consumption values presented below reflect federal standards governing appliance efficiency in the years specified by the LMI Appliance Baseline Standard Year Range column.[16] The baseline annual electric consumption (kWh/yr) shall align with federally mandated maximum energy use associated with the Product Class and Volume of the existing equipment.

[13] ENERGY STAR® Certified Residential Refrigerators Product Finder.
https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[14] ENERGY STAR® Certified Residential Freezers Product Finder.
https://www.energystar.gov/productfinder/product/certified certified -residential-freezers/results
[15] https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[16] ENERGY STAR® Flip your fridge calculator.
https://www.energystar.gov/products/appliances/refrigerators/flip-your-fridge

LMI Baseline Annual kWh Use based on Appliance Type and Size

Appliance Type	LMI Appliance Baseline Standard Year Range	LMI Size (ft^3)	LMI Baseline Annual kWh Use
Top Freezer Refrigerator	Before 1993	Below 16.5	1,272
		16.5-18.9	1,432
		19.0-21.4	1,539
		21.5-24.40	1,630
		24.5 +	1,839
	1993 - 2000	Below 16.5	861
		16.5-18.9	962
		19.0-21.4	1,031
		21.5-24.40	1,090
		24.5 +	1,223
	2001 - 2010	Below 16.5	556
		16.5-18.9	613
		19.0-21.4	651
		21.5-24.40	683
		24.5 +	758
	2011 - Present	Below 16.5	374
		16.5-18.9	412
		19.0-21.4	438
		21.5-24.40	459
		24.5 +	508
Bottom Freezer Re-frigerator	Before 1993	Below 16.5	1,519
		16.5-18.9	1,680
		19.0-21.4	1,786
		21.5-24.40	1,896
		24.5 +	2,210
	1993 - 2000	Below 16.5	962
		16.5-18.9	1,051
		19.0-21.4	1,110
		21.5-24.40	1,172
		24.5 +	1,347
	2001 - 2010	Below 16.5	724
		16.5-18.9	747
		19.0-21.4	762
		21.5-24.40	777
		24.5 +	822
	2011 - Present	Below 16.5	483
		16.5-18.9	517
		19.0-21.4	539
		21.5-24.40	562
		24.5 +	627

Appliance Type	LMI Appliance Baseline Standard Year Range	LMI Size (ft^3)	LMI Baseline Annual kWh Use
Side-by-Side Freezer Re-frigerator	Before 1993	Below 16.5	1,617
		16.5-18.9	1,873
		19.0-21.4	2,001
		21.5-24.40	2,080
		24.5 +	2,402
	1993 - 2000	Below 16.5	1,139
		16.5-18.9	1,266
		19.0-21.4	1,329
		21.5-24.40	1,368
		24.5 +	1,528
	2001 - 2010	Below 16.5	747
		16.5-18.9	818
		19.0-21.4	854
		21.5-24.40	876
		24.5 +	966
	2011 - Present	Below 16.5	314
		16.5-18.9	418
		19.0-21.4	479
		21.5-24.40	517
		24.5 +	677
French Door Refrigerator Freezer	Before 1993	Below 16.5	1,519
		16.5-18.9	1,680
		19.0-21.4	1,786
		21.5-24.40	1,896
		24.5 +	2,210
	1993 - 2000	Below 16.5	962
		16.5-18.9	1,051
		19.0-21.4	1,110
		21.5-24.40	1,172
		24.5 +	1,347
	2001 - 2010	Below 16.5	724
		16.5-18.9	747
		19.0-21.4	762
		21.5-24.40	777
		24.5 +	822
	2011 - Present	Below 16.5	483
		16.5-18.9	517
		19.0-21.4	539
		21.5-24.40	562
		24.5 +	627

Appliance Type	LMI Appliance Baseline Standard Year Range	LMI Size (ft^3)	LMI Baseline Annual kWh Use
4 Drawer Refrigerator Freezer	Before 1993	Below 16.5	1,519
		16.5-18.9	1,680
		19.0-21.4	1,786
		21.5-24.40	1,896
		24.5 +	2,210
	1993 - 2000	Below 16.5	962
		16.5-18.9	1,051
		19.0-21.4	1,110
		21.5-24.40	1,172
		24.5 +	1,347
	2001 - 2010	Below 16.5	724
		16.5-18.9	747
		19.0-21.4	762
		21.5-24.40	777
		24.5 +	822
	2011 - Present	Below 16.5	483
		16.5-18.9	517
		19.0-21.4	539
		21.5-24.40	562
		24.5 +	627
Upright Freezer	Before 1993	Below 16.5	1,343
		16.5-18.9	1,481
		19.0-21.4	1,573
		21.5-24.40	1,637
		24.5 +	1,821
	1993 - 2000	Below 16.5	937
		16.5-18.9	1,058
		19.0-21.4	1,138
		21.5-24.40	1,194
		24.5 +	1,355
	2001 - 2010	Below 16.5	713
		16.5-18.9	805
		19.0-21.4	866
		21.5-24.40	909
		24.5 +	1,031
	2011 - Present	Below 16.5	449
		16.5-18.9	507
		19.0-21.4	545
		21.5-24.40	572
		24.5 +	648

Appliance Type	LMI Appliance Baseline Standard Year Range	LMI Size (ft^3)	LMI Baseline Annual kWh Use
Chest Freezer	Before 1993	Below 16.5	773
		16.5-18.9	900
		19.0-21.4	985
		21.5-24.40	1,045
		24.5 +	1,215
	1993 - 2000	Below 16.5	532
		16.5-18.9	621
		19.0-21.4	680
		21.5-24.40	721
		24.5 +	840
	2001 - 2010	Below 16.5	435
		16.5-18.9	508
		19.0-21.4	557
		21.5-24.40	591
		24.5 +	688
	2011 - Present	Below 16.5	292
		16.5-18.9	341
		19.0-21.4	373
		21.5-24.40	396
		24.5 +	461

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a new ENERGY STAR® qualified refrigerator, refrigerator-freezer or freezer as defined in the Measure Description section above. This measure is not applicable to products purchased on the secondary market/post-retail. Annual energy consumption of the qualifying product must comply with current ENERGY STAR® Maximum Annual Energy Consumption Requirements[17] and shall be determined from the directory of ENERGY STAR® qualified Refrigerators[18] and Freezers[19] according to the make and model of the qualifying equipment. It is required that the units being replaced are recycled and permanently decommissioned.

Where test data is not available, but qualifying product is confirmed to be ENERGY STAR® compliant, efficient case annual electric consumption (kWh_{ee}) may be calculated per the table below based on Product Class and Adjusted Volume (AV in ft^3 or av in L).

[17] ENERGY STAR® Program Requirements Product Specification for Consumer Refrigeration Products, Eligibility Criteria Version 5.1, August 2021.
[18] ENERGY STAR® Certified Residential Refrigerators Product Finder.
https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[19] ENERGY STAR® Certified Residential Freezers Product Finder.
https://www.energystar.gov/productfinder/product/certified-residential-freezers/results

Product Class	kWh_{ee} (AV in ft^3)	kWh_{ee} (av in L)
Standard Size Models: 7.75 cubic feet or greater		
1. Refrigerator-freezers and refrigerators (other than all-refrigerators) with manual defrost.[20]	7.19AV + 202.5	0.254av + 202.5
1A. All-refrigerators—manual defrost.	6.11AV + 174.2	0.216av + 174.2
2. Refrigerator-freezers—partial automatic defrost	7.19AV + 202.5	0.254av + 202.5
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	7.26AV + 210.3	0.256av + 210.3
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	8.24AV + 238.4	0.291av + 238.4
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	7.26AV + 294.3	0.256av + 294.3
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	8.24AV + 322.4	0.291av + 322.4
3A. All-refrigerators—automatic defrost.	6.36AV + 181.4	0.225av + 181.4
3A-BI. Built-in All-refrigerators—automatic defrost.	7.22AV + 205.7	0.255av + 205.7
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	7.66AV + 268.0	0.271av + 268.0
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	9.20AV + 321.7	0.325av + 321.7
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	7.66AV + 352.0	0.271av + 352.0
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	9.20AV + 405.7	0.325av + 405.7
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with-out an automatic icemaker.	7.97AV + 285.3	0.281av + 285.3
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	8.46AV + 303.2	0.299av + 303.2
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	7.97AV + 369.3	0.281av + 369.3
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	8.46AV + 387.2	0.299av + 387.2
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	8.33AV + 436.3	0.294av + 436.3
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	8.85AV + 458.3	0.313av + 458.3
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	7.56AV + 355.3	0.267av + 355.3
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	7.69AV + 397.9	0.272av + 397.9
7-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	9.23AV + 460.7	0.326av + 460.7
8. Upright freezers with manual defrost	5.01AV + 174.3	0.177av + 174.3

[20] This Product Class represents products defined as “Refrigerator-Freezer” and “Refrigerator” per the Code of Federal Regulations with manual defrost. It explicitly excludes products defined as “All-refrigerator” with manual defrost, which is the scope of Product Class 1A.

Product Class	kWh_{ee} (AV in ft^3)	kWh_{ee} (av in L)
9. Upright freezers with automatic defrost without an automatic icemaker	7.76AV + 205.5	0.274av + 205.5
9I. Upright freezers with automatic defrost with an automatic icemaker	7.76AV + 289.5	0.274av + 289.5
9–BI. Built-In Upright freezers with automatic defrost without an automatic icemaker	8.87AV + 234.8	0.313av + 234.8
9I–BI. Built-in upright freezers with automatic defrost with an automatic ice-maker	8.87AV + 318.8	0.313av + 318.8
10. Chest freezers and all other freezers except compact freezers	6.56AV + 97.0	0.232av + 97.0
10A. Chest freezers with automatic defrost	9.22AV + 133.3	0.326av + 133.3
Compact Size Models: Less than 7.75 cubic feet and 36 inches or less in height		
11. Compact refrigerator-freezers and refrigerators (other than all-refrigerators) with manual defrost.[21]	8.13AV + 227.1	0.287av + 227.1
11A.Compact all-refrigerators—manual defrost.	7.06AV + 197.2	0.249av + 197.2
12. Compact refrigerator-freezers—partial automatic defrost	5.32AV + 302.2	0.188av + 302.2
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	10.62AV + 305.3	0.375av + 305.3
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	10.62AV + 389.3	0.375av + 389.3
13A. Compact all-refrigerators—automatic defrost.	8.25AV + 233.4	0.291av + 233.4
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	6.14AV + 411.2	0.217av + 411.2
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	6.14AV + 495.2	0.217av + 495.2
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	10.62AV + 305.3	0.375av + 305.3
15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker.	10.62AV + 389.3	0.375av + 389.3
16. Compact upright freezers with manual defrost	7.79AV + 203.1	0.275av + 203.1
17. Compact upright freezers with automatic defrost	9.15AV + 316.7	0.323av + 316.7
18. Compact chest freezers	8.33AV + 123.1	0.294av + 123.1

Operating Hours

Refrigeration products are assumed to be plugged into an electrical outlet 8,760 hours per year. Compressor cycling is inherent in the specified annual energy consumption of baseline and qualifying equipment.

[21] This Product Class represents products defined as “Compact Refrigerator-Freezer” and “Compact Refrigerator” per the Code of Federal Regulations with manual defrost. It explicitly excludes products defined as “Compact All-refrigerator” with manual defrost, which is the scope of Product Class 11A.

Example Calculation *(Not to be used as default)*

An existing residential customer living in single-family home with 4 occupants in NYC equipped with air conditioning and fuel heat installs a 20 ft^3 ENERGY STAR® compliant refrigerator-freezer with automatic defrost, side-mounted freezer, and through-the-door ice service, which has 550 kWh annual electric energy consumption. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times (kWh_{baseline} - kWh_{ee}) \times (1 + HVAC_c) \times F_{occ}$$

$$\Delta kW = units \times \left(\frac{kWh_{baseline} - kWh_{ee}}{8{,}760}\right) \times (1 + HVAC_d) \times CF$$

$$\Delta MMBtu = units \times (kWh_{baseline} - kWh_{ee}) \times HVAC_{ff} \times F_{occ}$$

units = 1, from application
$kWh_{baseline}$ = 8.54 AV + 432.8 = (8.54 x 20) + 432.8 = 604 kWh/yr, per the Baseline Efficiencies table above based on product type (7)
kWh_{ee} = 550 kWh/yr, from application
$HVAC_c$ = 0.077, from Appendix D based on location, HVAC configuration, and facility type
$HVAC_d$ = 0.085, from Appendix D based on location, HVAC configuration, and facility type
$HVAC_{ff}$ = -0.002, from Appendix D based on location, HVAC configuration, and facility type
F_{occ} = 1.15, from Occupant Adjustment Factor table based on occupancy from application
CF =1.0, from Summary of Variables and Data Sources table

$$\Delta kWh = 1 \times (604 - 550) \times (1 + 0.077) \times 1.15 = 66.9\ kWh$$

$$\Delta kW = 1 \times \left(\frac{604 - 550}{8{,}760}\right) \times (1 + 0.085) \times 1 = 0.007\ kW$$

$$\Delta MMBtu = 1 \times (604 - 550) \times (-0.002) \times 1.15 = -0.124\ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

High-efficiency refrigeration products reject less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

Ancillary Electric Savings Impacts

High-efficiency refrigeration products reject less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

References

1. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=39bdf94d4be5c5dac50be36d83225fe4&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132
2. ENERGY STAR® Refrigerators & Freezers Key Product Criteria, August 5, 2021. Available from: https://www.energystar.gov/products/appliances/refrigerators/key_product_criteria
3. Purchase energy-saving products, Savings Calculator for ENERGY STAR® Qualified Appliances
   Available from: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products
4. Oak Ridge National Laboratory, National Energy Audit Tool (NEAT), 2012. Available from: https://weatherization.ornl.gov/obtain/
5. ENERGY STAR® Program Requirements Product Specification for Consumer Refrigeration Products, Eligibility Criteria Version 5.1, August 2021. Available from: https://www.energystar.gov/sites/default/files/asset/document/Refrigerators_and_Freezers_Program_Requirements_V5.1.pdf
6. ENERGY STAR® Certified Residential Refrigerators Product Finder. Available from: https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
7. ENERGY STAR® Certified Residential Freezers Product Finder. Available from: https://www.energystar.gov/productfinder/product/certified-residential-freezers/results
8. 10 CFR 430 Subpart B, Appendix A – Uniform Test Method for Measuring the Energy Consumption of Refrigerators, Refrigerator-Freezers, and Miscellaneous Refrigeration Products.
   Available from https://www.ecfr.gov/cgi-bin/text-idx?SID=39bdf94d4be5c5dac50be36d83225fe4&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.b
9. 10 CFR 430 Subpart B, Appendix B – Uniform Test Method for Measuring the Energy Consumption of Freezers.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=39bdf94d4be5c5dac50be36d83225fe4&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.b
10. ENERGY STAR®, Flip your fridge calculator. Available from: https://www.energystar.gov/products/appliances/refrigerators/flip-your-fridge

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-3	7/31/2013
7-13-41	7/31/2013
9-13-1	9/27/2013
3-18-7	3/29/2018
6-22-2	9/2/2022
3-24-1	3/29/2024

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DOMESTIC HOT WATER – CONTROL

LOW-FLOW - FAUCET AERATOR

Measure Description

This measure covers the installation of low-flow aerators on residential faucets. A low-flow faucet aerator is a water saving device with rated gallons per minute (gpm) less than maximum allowable flowrate as mandated by federal, state, local and municipal codes and standards. Energy savings are realized through the decreased demand for hot water during faucet use. New York State appliance standards require compliance with California Title 20 code[22], which dictates a maximum flowrate of 1.2 gpm for lavatory faucets and 1.8 gpm elsewhere. This is a retrofit direct install measure or a new installation in a residential application.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Water Heating Only)

$$\Delta kWh = units \times H_2O_{savings} \times \Delta T_{main} \times \frac{8.33}{3{,}412} \times \frac{1}{UEF}$$

Summer Peak Coincident Demand Savings (Electric Water Heating Only)

$$\Delta kW = Negligible$$

Annual Fossil Fuel Energy Savings (Fossil Fuel Water Heating Only)

$$\Delta MMBtu = units \times H_2O_{savings} \times \Delta T_{main} \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{UEF}$$

Note: to estimate the annual gallons of water saved from installation of measure:

$$H_2O_{savings} = \left(GPM_{baseline} \times Throttle_{fac,baseline} - GPM_{ee} \times Throttle_{fac,ee}\right) \times \frac{1}{\mathrm{F}_{faucet}} \times \frac{minutes}{person/day} \times \frac{person}{household} \times 365$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
$H_2O_{savings}$	= Annual Water savings (gallons)
ΔT_{main}	= Average temperature difference between faucet operating temperature and the

[22] California Energy Commission (Title 20)

supply water temperature in water main (°F)
UEF = Uniform Energy Factor
$_{baseline}$ = Characteristic of baseline condition
$_{ee}$ = Characteristic of energy efficient condition
GPM = Gallon per minute
$Throttle_{fac}$ = Throttle factor
F_{faucet} = Faucets per household factor
8.33 = Specific heat of water; energy required (BTU), to heat one gallon of water by one degree Fahrenheit [BTU/(gal-F)]
365 = Days in one year
3,412 = Conversion factor, one kW equals 3,412 BTU/h
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$	Kitchen: 1.8 Lavatory: 1.2 Unknown: 1.2	GPM for baseline measure, based on faucet type.[23]
$Throttle_{fac,baseline}$	0.83	American Council for an Energy-Efficient Economy.[24]
GPM_{ee}	Kitchen: 1.5 Lavatory: 1.0 Unknown: 1.0	From application. If unknown, assume minimum flow rates for compliance.
$Throttle_{fac,ee}$	0.95	American Council for an Energy-Efficient Economy.[25]
F_{faucet}	Non-lavatory: 1 Lavatory: 1.6 Unknown: 1.6	Factor reflecting the number of faucets in an average New York household.[26]
minutes/ person/day	Non-lavatory: 4.5 Lavatory: 1.6 Unknown: 1.6	Metered water consumption based on faucet type.[27]

[23] Table H-4, California Energy Commission (Title 20) via NYS Appliance Standards.
[24] Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008, pg. 1-265.
[25] Ibid.
[26] American Housing Survey Table Creator, United States Census Bureau, Housing Unit Characteristics, New York 2017. The lavatory faucet factor was calculated by taking the average number of complete or half bathrooms per household.
[27] Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study. June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015, Table 93.

Variable	Value	Notes
person/ household	Single-family: 2.8 Multi-family: 2.0 Unknown: 2.5	Persons per household, from application. If unknown, use prescribed default values based on housing type.[28,29,30]
$H_2O_{savings}$	Non-lavatory, SF: 317 Non-lavatory, MF: 227 Lavatory, SF: 48 Lavatory, MF: 34 Unknown: 34	Calculated gallons of water saved per year based on default values of installation of energy efficient measure, from application.
ΔT_{main}	$T_{faucet} - T_{main}$	Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F).
T_{faucet}	Non-Lavatory: 93 Lavatory: 86 Unknown: 88	Faucet operating temperature (°F)[31]. Unknown is derived from the calculated weighted average based on statewide average assumptions: ((1*93)+(3*86))/(1+3)= 88
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern).[32]

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[33] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[34] (°F)	T_{main} (°F)
Albany	49.4	55.4
Binghamton	46.8	52.8
Buffalo	49.1	55.1
Massena	45.1	51.1
NYC	54.7	60.7

[28] Residential Statewide Baseline Study of New York State, July 2015. Volume 1: Single-Family Report, Table 9.
[29] Residential Statewide Baseline Study of New York State, July 2015. Volume 2: Multifamily Report, Table 8.
[30] "Unknown" value established as the average of Single-family and Multi-family values, weighted based on ratio of single-family (~61%) and apartment (~39%) housing unit type counts for the Middle Atlantic States from EIA Residential Energy Consumption Survey (RECS) 2020, Table HC2.1
[31] Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study. June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015, Table 93.
[32] 10 CFR 430.32(d); medium draw pattern default assumption based on review of typical usage bins for AHRI certified residential water heating equipment. (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[33] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
[34] Average annual outdoor temperatures taken from NCEI 1991-2020 climate normals.

City	Annual average outdoor temperature[34] (°F)	T_{main} (°F)
Poughkeepsie	50.9	56.9
Syracuse	49.0	55.0

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A.

Baseline Efficiencies from which Energy Savings are Calculated

The Summary of Variables and Data Sources provides the baseline (standard) and low flow aerator water flows, related input assumptions, and the resulting water savings. Assumptions regarding average duration of use and number of uses per day are also presented. Uniform Energy Factor is determined for the assumed water heater system configurations cited per the table below (from Code of Federal Regulations 10 CFR 430.32(d)).

UEF shall be calculated as a function of existing equipment tank volume (v_t) with the appropriate equation, looked up based on existing equipment type, capacity and draw pattern. Draw pattern can be established based on the existing equipment First Hour Rating (FHR), rated in gallons; see the First Hour Rating vs. Draw Pattern table below.

If FHR is unknown, a Medium draw pattern should be assumed for storage type water heaters with rated storage capacity ≤ 50 gallons and a High draw pattern should be assumed otherwise.[35] If the type of existing water heater cannot be identified due to program delivery mechanism, assume 40-gallon rated storage volume, medium draw storage type system with primary water heater fuel from application.

Residential Water Heaters

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.3456 - (0.0020 x v_t^*)
		Low	0.5982 - (0.0019 x v_t)
		Medium	0.6483 - (0.0017 x v_t)
		High	0.6920 - (0.0013 x v_t)
	> 55 gal and ≤ 100 gal	Very Small	0.6470 - (0.0006 x v_t)
		Low	0.7689 - (0.0005 x v_t)
		Medium	0.7897 - (0.0004 x v_t)
		High	0.8072 - (0.0003 x v_t)
Oil-Fired Storage Water Heater	≤50 gal	Very Small	0.2509 - (0.0012 x v_t)
		Low	0.5330 – (0.0016 x v_t)
		Medium	0.6078 – (0.0016 x v_t)
		High	0.6815 - (0.0014 x v_t)

[35] Based on review of typical usage bins for AHRI certified residential water heating equipment. (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x v_t)
		Low	0.9254 - (0.0003 x v_t)
		Medium	0.9307 - (0.0002 x v_t)
		High	0.9349 - (0.0001 x v_t)
	> 55 gal and ≤ 120 gal	Very Small	1.9236 - (0.0011 x v_t)
		Low	2.0440 - (0.0011 x v_t)
		Medium	2.1171 - (0.0011 x v_t)
		High	2.2418 - (0.0011 x v_t)
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*v_t = Rated Storage Volume (gal)

First Hour Rating vs. Draw Pattern[36]

First Hour Rating	Draw Pattern
< 18 gallons	Very Small
≥ 18 and < 51 gallons	Low
≥ 51 and < 75 gallons	Medium
≥ 75 gallons	High

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a lavatory faucet aerator with a flowrate of 1.0 GPM or less or a non-lavatory faucet aerator with a flowrate of 1.5 GPM or less.

Operating Hours

Non-lavatory faucet aerators are assumed to be in use 4.5 minutes per day per person and lavatory faucets are assumed to be in use 1.6 minutes per day per person. All faucet aerators are assumed to be available 365 days per year.

Example Calculation *(Not to be used as default)*

Two 0.5 GPM low-flow faucet aerators are installed on lavatory sinks in a single-family home located near Albany. The residence's gas-fired storage tank water heater has 40 gallon capacity and first hour recovery rating of 68 GPH. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are not applicable. Annual Fossil Fuel Energy Savings are

[36] 10 CFR 429.17.

calculated as below.

$$\Delta MMBtu = units \times H_2O_{savings} \times \Delta T_{main} \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{UEF}$$

$$H_2O_{savings} = \left(GPM_{baseline} \times Throttle_{fac,baseline} - GPM_{ee} \times Throttle_{fac,ee}\right) \times \frac{1}{F_{faucet}} \times \frac{minutes}{person/day} \times \frac{person}{household} \times 365$$

units = 2, from application
$GPM_{baseline}$ = 1.2, from Summary of Variables and Data Sources table
$Throttle_{fac,baseline}$ = 0.83, from Summary of Variables and Data Sources table
GPM_{ee} = 0.5, from application
$Throttle_{fac,ee}$ = 0.95, , from Summary of Variables and Data Sources table
$F_{facucet}$ = 1.6, from Summary of Variables and Data Sources table based on sink location
Minutes/person/day = 1.6, from Summary of Variables and Data Sources table based on sink location
Person/household = 2.8, from Summary of Variables and Data Sources table based on application
$\Delta T_{main} = T_{faucet} - T_{main} = 86 - 55.4 = 30.6$
T_{faucet} from Summary of Variables and Data Sources table based on sink location
T_{main} from Cold Water Inlet Temperature lookup table based on location from application
UEF = $0.6483 - (0.0017 \times v_t) = 0.6483 - (0.0017 \times 40) = 0.5803$
$UEF_{baseline}$ equation from Residential Water Heaters table based on product class and draw pattern from application
V_t from application

$$H_2O_{savings} = (1.2 \times 0.83 - 0.5 \times 0.95) \times \frac{1}{1.6} \times 1.6 \times 2.8 \times 365 = 53.24$$

$$\Delta MMBtu = 2 \times 53.24 \times 30.6 \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{0.5803} = 0.046\ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

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1	10/15/2010
6-13-5	6/30/2013
7-13-7	7/31/2013
6-17-2	6/30/2017
3-19-5	3/29/2019
6-19-5	6/28/2019
3-24-2	3/29/2024

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DOMESTIC HOT WATER – CONTROL

LOW-FLOW - SHOWERHEAD

Measure Description

This measure covers the installation of low-flow showerheads. A low-flow showerhead is a water saving showerhead with rated gallons per minute (gpm) less than maximum allowable flowrate as mandated by federal, state, local and municipal codes and standards. Energy savings are realized through the decreased demand for hot water during shower use. New York State appliance standards require compliance with California Title 20 code[37], which dictates a maximum flowrate of 1.8 gpm for showerheads. This is a retrofit direct install measure or a new installation in a residential application.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Water Heating Only)

$$\Delta kWh = units \times H_2O_{savings} \times (T_{shower} - T_{main}) \times \frac{8.33}{3{,}412} \times \frac{1}{UEF}$$

Summer Peak Coincident Demand Savings (Electric Water Heating Only)

$$\Delta kW = Negligible$$

Annual Fossil Fuel Energy Savings (Fossil Fuel Water Heating Only)

$$\Delta MMBtu = units \times H_2O_{savings} \times (T_{shower} - T_{main}) \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{UEF}$$

Note: to estimate the annual gallons of water saved from installation of measure:

$$H_2O_{savings} = (GPM_{baseline} - GPM_{ee}) \times Throttle_{fac} \times \frac{1}{\mathrm{F}_{shower}} \times \frac{minutes}{use} \times \frac{uses}{person/day} \times \frac{person}{household} \times 365$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
$H_2O_{savings}$	= Water savings
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition

[37] California Energy Commission (Title 20) via NYS Appliance Standard

GPM = Gallon per minute
$Throttle_{fac}$ = Throttle factor
F_{shower} = Shower Factor
T_{shower} = Temperature (ºF) at showerhead
T_{main} = Temperature (ºF) of supply water from main
UEF = Uniform Energy Factor
8.33 = Specific heat of water; energy required (BTU), to heat one gallon of water by one degree Fahrenheit [BTU/(gal-F)]
365 = Days in one year
3,412 = Conversion factor, one kW equals 3,412 BTU/h
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		Gallons per minute for energy efficient measure, from application.
$GPM_{baseline}$		For LMI projects, flowrate shall come from application or default to 2.5 GPM.[38] Otherwise, use 1.8 GPM.[39]
$Throttle_{fac}$	0.9	Used in LBNL study to adjust for average percent of full capacity that the shower valve is opened when in use.[40]
F_{shower}	1.4	Factor capturing average number of showers per household.[41]
minutes/use	8.2	Average shower duration per LBNL study.[42]
uses/person/day	0.75	LBNL showers per day per capita.[43]
person/ household	Single-family: 2.8 Multi-family: 2.0 Unknown: 2.5	Persons per household, from application. If unknown, use prescribed default values based on housing type.[44,45,46]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.

[38] The Energy Policy Act (EPAct) of 1992 (https://afdc.energy.gov/files/pdfs/2527.pdf).
[39] Table H-4, California Energy Commission (Title 20) via NYS Appliance Standards.
[40] LBNL: Potential Water and Energy Savings from Showerheads, March 2006.
[41] United States Census Bureau, American Housing Survey – Table Creator, New York, 2017, Housing Unit Characteristics. The shower factor was calculated by taking the average number of complete bathrooms per household. Granularity at the single vs. multifamily level was not available.
[42] LBNL: Potential Water and Energy Savings from Showerheads, March 2006.
[43] Ibid.
[44] Residential Statewide Baseline Study of New York State, July 2015. Volume 1: Single-Family Report, Table 9.
[45] Residential Statewide Baseline Study of New York State, July 2015. Volume 2: Multifamily Report, Table 8.
[46] "Unknown" value established as the average of Single-family and Multi-family values, weighted based on ratio of single-family (~61%) and apartment (~39%) housing unit type counts for the Middle Atlantic States from EIA Residential Energy Consumption Survey (RECS) 2020, Table HC2.1

Variable	Value	Notes
T_{shower}	104	Average temperature at showerhead.[47]
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern).[48]

Cold Water Inlet Temperature (T_{main})
Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[49] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[50] (°F)	T_{main} (°F)
Albany	49.4	55.4
Binghamton	46.8	52.8
Buffalo	49.1	55.1
Massena	45.1	51.1
NYC	54.7	60.7
Poughkeepsie	50.9	56.9
Syracuse	49.0	55.0

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A.

Baseline Efficiencies from which Energy Savings are Calculated

The Summary of Variables and Data Sources provides the baseline (standard) water flow and related input assumptions. Assumptions regarding average duration of use and number of uses per day are also presented. Uniform Energy Factor (UEF) is determined for the assumed water heater system configurations cited per the table below (from Code of Federal Regulations 10 CFR 430.32(d)).

UEF shall be calculated as a function of existing equipment tank volume (v_t) with the appropriate equation, looked up based on existing equipment type, capacity and draw pattern. Draw pattern can be established based on the existing equipment First Hour Rating (FHR), rated in gallons; see the First Hour Rating vs. Draw Pattern table below.

If FHR is unknown, a Medium draw pattern should be assumed for storage type water heaters with

[47] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014.
[48] 10 CFR 430.32(d); medium draw pattern default assumption based on review of typical usage bins for AHRI certified residential water heating equipment. (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[49] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
[50] Average annual outdoor temperatures taken from NCEI 1991-2020 climate normals.

rated storage capacity ≤ 50 gallons and a High draw pattern should be assumed otherwise.[51] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a 40-gallon rated storage volume, Medium draw storage type system with primary water heater fuel from application.

Residential Water Heaters

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.3456 - (0.0020 \times v_t^*)$
		Low	$0.5982 - (0.0019 \times v_t)$
		Medium	$0.6483 - (0.0017 \times v_t)$
		High	$0.6920 - (0.0013 \times v_t)$
	> 55 gal and ≤ 100 gal	Very Small	$0.6470 - (0.0006 \times v_t)$
		Low	$0.7689 - (0.0005 \times v_t)$
		Medium	$0.7897 - (0.0004 \times v_t)$
		High	$0.8072 - (0.0003 \times v_t)$
Oil-Fired Storage Water Heater	≤50 gal	Very Small	$0.2509 - (0.0012 \times v_t)$
		Low	$0.5330 – (0.0016 \times v_t)$
		Medium	$0.6078 – (0.0016 \times v_t)$
		High	$0.6815 - (0.0014 \times v_t)$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.8808 - (0.0008 \times v_t)$
		Low	$0.9254 - (0.0003 \times v_t)$
		Medium	$0.9307 - (0.0002 \times v_t)$
		High	$0.9349 - (0.0001 \times v_t)$
	> 55 gal and ≤ 120 gal	Very Small	$1.9236 - (0.0011 \times v_t)$
		Low	$2.0440 - (0.0011 \times v_t)$
		Medium	$2.1171 - (0.0011 \times v_t)$
		High	$2.2418 - (0.0011 \times v_t)$
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*v_t = Rated Storage Volume (gal)

First Hour Rating vs. Draw Pattern[52]

First Hour Rating	Draw Pattern
< 18 gallons	Very Small
≥ 18 and < 51 gallons	Low

[51] Based on review of typical usage bins for AHRI certified residential water heating equipment. (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[52] 10 CFR 429.17.

First Hour Rating	Draw Pattern
≥ 51 and < 75 gallons	Medium
≥ 75 gallons	High

Compliance Efficiency from which Incentives are Calculated

Compliance flow rate is less than the specified baseline value (<1.8 gpm) or less than the more restrictive codes or guidelines of local governments, municipalities or entities which, for example, participate in the US EPA Water Sense® Partnership Program.[53]

Operating Hours

Estimate of energy savings assumes an average duration of 8 minutes, 12 seconds per shower event, 0.75 showers per person per day, and 2.8 persons per single - family home and 2.0 persons per multifamily home.

Example Calculation *(Not to be used as default)*

Two 1.0 GPM low-flow showerheads are installed in a single-family home located near Albany. The residence's gas-fired storage tank water heater has 40 gallon capacity and first hour recovery rating of 68 GPH. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are not applicable. Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta MMBtu = units \times H_2O_{savings} \times (T_{shower} - T_{main}) \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{UEF}$$

$$H_2O_{savings} = (GPM_{baseline} - GPM_{ee}) \times Throttle_{fac} \times \frac{1}{F_{shower}} \times \frac{minutes}{use} \times \frac{uses}{person/day} \times \frac{person}{household} \times 365$$

units = 2, from application
$GPM_{baseline}$ = 1.8, from Summary of Variables and Data Sources table
GPM_{ee} = 1.0, from application
$Throttle_{fac}$ = 0.9, from Summary of Variables and Data Sources table
F_{shower} = 1.4, from Summary of Variables and Data Sources table
Minutes/use = 8.2, from Summary of Variables and Data Sources table
Uses/person/day = 0.75, from Summary of Variables and Data Sources table
Person/household = 2.8, from Summary of Variables and Data Sources table based on application
T_{shower} = 104, from Summary of Variables and Data Sources table
T_{main} = 55.4, from Cold Water Inlet Temperature lookup table based on location from application
UEF = 0.6483 – (0.0017 x v_t) = 0.6483 – (0.0017 x 40) = 0.5803

[53] Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory

$UEF_{baseline}$ equation from Residential Water Heaters table based on product class and draw pattern from application
V_t from application

$$H_2O_{savings} = (1.8 - 1.0) \times 0.9 \times \frac{1}{1.4} \times 8.2 \times 0.75 \times 2.8 \times 365 = 3232.44$$

$$\Delta MMBtu = 2 \times 3232.44 \times (104 - 55.4) \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{0.5803} = 4.51\ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

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Record of Revision

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6-15-1	6/15/2015
6-17-4	6/30/2017
3-19-7	3/29/2019
6-19-6	6/28/2019
7-21-22	8/30/2021
3-24-3	3/29/2024

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTAT - PROGRAMMABLE SETBACK

Measure Description

This measure covers the installation of programmable setback thermostats applied to single-family and multi-family residential air conditioners, heat pumps, boilers, furnaces, and electric resistance baseboard heating systems.

One programmable thermostat may be applied to each controlled HVAC system. This measure is applicable for all products equipped with programmable functionality, including Wi-Fi and DR-enabled devices that do not meet all requirements specified in the current, effective ENERGY STAR® specification for Connected Thermostats.[54]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\left(tons/unit \times \frac{12}{Eff_{cooling}} \times EFLH_{cooling} \times ESF_{cooling}\right) + \left((kBTU/h)_{out}/unit \times \frac{1}{HSPF} \times EFLH_{heating} \times ESF_{heating}\right)\right]$$

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \left((kBTU/h)_{in}/unit \times \frac{1}{1{,}000} \times EFLH_{heating} \times ESF_{heating}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of residences in which the measure is installed under the program
tons/unit	= Tons of air conditioning per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total cooling capacity of the system divided by the total number of dwelling units it serves

[54] ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0, January 2017.

$(kBTU/h)_{out}$/unit= Output electric heating capacity in kBTU/h per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total heating capacity of the system divided by the total number of dwelling units it serves

$(kBTU/h)_{in}$/unit = Input heating capacity in kBTU/h per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total heating capacity of the system divided by the total number of dwelling units it serves

$Eff_{cooling}$ = Seasonal average energy efficiency over the cooling season, BTU/watt-hour, (used for average U.S. location/region), using either SEER (<5.4 tons) or IEER (≥5.4 tons)

HSPF = Seasonal average energy efficiency over the heating season, Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heat) during the heating season / total electric energy heat pump consumed (in watt-hour); if equipment efficiency is reported in COP, convert to HSPF using the equivalency HSPF = COP x 3.412

$EFLH_{cooling}$ = Cooling equivalent full-load hours

$EFLH_{heating}$ = Heating equivalent full-load hours

ESF = Energy savings factor

12 = (kBTU/h)/ton of air conditioning capacity

1,000 = Conversion factor, one MMBtu equals 1,000 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application or use 3 tons as a default.[55]
$(kBTU/h)_{out}$/unit		From application or use 72 kBTU/h as a default.[56]
$(kBTU/h)_{in}$/unit		From application or use 90 kBTU/h as a default.[57]
$Eff_{cooling}$		From application or use 14 SEER, assuming a 3-ton central ASHP system.[58] For equipment rated in SEER2, SEER2 rating shall be used.
HSPF		From application or use 8.2 HSPF, assuming a 3-ton central ASHP system.[59] For electric resistance heating and electric furnaces, use 3.4 HSPF. If taken from application, COP must be converted to HSPF using the equivalency HSPF = COP x 3.412. For equipment rated in HSPF2, HSPF2 rating shall be used.

[55] Assumes a 1,800 ft^2 home with 20 BTU/h-ft^2 cooling load: 1,800 ft^2 x 20 BTU/h-ft^2 x 1/12,000 ton/(BTU/h) = 3 tons.

[56] Assumes a 1,800 ft^2 home with 40 BTU/h-ft^2 heating load: 1,800 ft^2 x 40 BTU/h-ft^2 x 1/(1,000 kBTU/h)/(BTU/h) = 72 kBTU/h.

[57] Assumes a 1,800 ft^2 home with 40 BTU/h-ft^2 heating load and 80% AFUE: 1,800 ft^2 x 40 BTU/h-ft^2 x 1/0.80 x 1/(1,000 kBTU/h)/(BTU/h) = 90 kBTU/h.

[58] 10 CFR 430.32 (c)(1).

[59] Ibid.

Variable	Value	Notes
$EFLH_{cooling}$		Look up based on building type, vintage and city in Appendix G.
$EFLH_{heating}$		Look up based on building type, vintage and city in Appendix G.
$ESF_{cooling}$	0.090	Energy savings factor for cooling.[60]
$ESF_{heating}$	0.041	Energy savings factor for heating.[61]

The nominal rating of the cooling capacity of the air conditioner or heat pump should be set equal to the rated capacity of all cooling equipment in the residence. The energy savings should be calculated based on the capacity of the HVAC system, with one thermostat controlling the system. For multifamily with central HVAC, total cooling capacity of the system should be used.

The nominal rating of the heating capacity of the heat pump should be set equal to the rated capacity of all heating equipment controlled in the residence. The energy savings should be calculated based on the capacity of the HVAC system, with one thermostat controlling the system. For multifamily with central HVAC, total heating capacity of the system should be used.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline system is a standard, non-programmable thermostat for a central heating and cooling system when a programmable thermostat is not otherwise required by applicable energy conservation code. If programmable thermostats are required by code, no savings may be claimed.

The baseline efficiency for air conditioners and heat pumps should be set according to the sections on air conditioner and heat pump efficiency above. Electric resistance heating systems should use an HSPF = 3.412, which is equivalent to a coefficient of performance of 1.0.

Studies of residential heating thermostat set point behavior indicate some amount of manual setback adjustment in homes without programmable thermostats. This behavior is accounted for in the prototypical building simulation model used to calculate heating equivalent full-load hours, as described in Appendix A. An assumption of 3°F of nighttime setback behavior is embedded in the models.

Compliance Efficiency from which Incentives are Calculated

The energy savings factor for heating ($ESF_{heating}$) is the result of a Guidehouse report evaluating programmable thermostats replacing manual thermostats.

[60] ENERGY STAR® Calculator "Life Cycle Cost Estimate for ENERGY STAR Qualified Programmable Thermostat(s)", which applies 6% savings per degree of setback. This measure assumes an additional average cooling season nighttime/unoccupied setback of 1.5 degrees (6% x 1.5 = 9%).
[61] Guidehouse, "Residential Wi-Fi and Programmable Thermostat Impacts", September 2021. Table 16.

The cooling energy savings factor ($ESF_{cooling}$) is the ratio of the energy savings resulting from installation of a programmable setback thermostat to the annual cooling energy. The cooling energy savings factor assumption is taken from the ENERGY STAR® website. The ENERGY STAR® calculator estimates an energy savings of 6% of the annual cooling energy consumption per degree of setback for programmable setback thermostats in residential applications. This measure assumes an average of 1.5 degrees of setback over the cooling season for an estimated annual cooling energy savings of 9%.

Operating Hours

Cooling and heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for single and multi-family buildings in NY are shown in Appendix G.

Example Calculation *(Not to be used as default)*

A programmable setback thermostat is installed in single-family detached home located near Albany constructed in 1995. The home is cooled by a 2.5-ton air conditioner with an efficiency of 14 SEER and heated by an 80 kBTUh gas-fired furnace. Summer Peak Coincident Demand Savings are not applicable. Annual Electric Energy Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times \left[\left(tons/unit \times \frac{12}{Eff_{cooling}} \times EFLH_{cooling} \times ESF_{cooling}\right) + \left((kBTU/h)_{out}/unit \times \frac{1}{HSPF} \times EFLH_{heating} \times ESF_{heating}\right)\right]$$

$$\Delta MMBtu = units \times \left((kBTU/h)_{in}/unit \times \frac{1}{1{,}000} \times EFLH_{heating} \times ESF_{heating}\right)$$

units = 1, from application
tons/unit = 2.5, from application
$Eff_{cooling}$ = 14, from application
$EFLH_{cooling}$ = 358, from Appendix G based on housing type, building vintage, and location from application.
$ESF_{cooling}$ = 0.090, from Summary of Variables and Data Sources table
$F_{ElecCool}$ = 1, from Summary of Variables and Data Sources table based on application
$(kBTU/h)_{out}$/unit = N/A based on application
HSPF = N/A based on application
$F_{ElecHeat}$ = 0, from Summary of Variables and Data Sources table based on application
$(kBTU/h)_{in}$/unit = 80, from application
$EFLH_{heating}$ = 933, from Appendix G based on housing type, building vintage, and location from application
$ESF_{heating}$ = 0.041, from Summary of Variables and Data Sources table

$F_{FuelHeat}$ = 1, from Summary of Variables and Data Sources table based on application

$$\Delta kWh = 1 \times \left[\left(2.5 \times \frac{12}{14} \times 358 \times 0.09 \times 1\right) + (0)\right] = 69.04\ kWh$$

$$\Delta MMBtu = 1 \times \left(80 \times \frac{1}{1{,}000} \times 933 \times 0.041 \times 1\right) = 3.06\ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Reduced operating hours during the heating and cooling season result in distribution blower electric savings. These effects are not quantified in the prescribed savings estimation methodology for this measure at this time.

References

1. ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0, January 2017.
   Available from: https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf
2. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
3. For examples of studies on residential thermostat set point behavior, see the literature review conducted for the California Energy Commission project "Residential Thermostats: Comfort Controls in California Homes," CEC-500-03-026.
   Available from: http://eta-publications.lbl.gov/sites/default/files/lbnl-938e.pdf
4. Baseline thermostat setback assumptions taken from: Conner, C.C. and Lucas, R.L. 1990. Thermostat Related Behavior and Internal Temperatures Based on Measured Data in Residences. PNL-7465, Pacific Northwest Laboratory. Richland, WA.
   Available from: http://elcap.nwcouncil.org/Documents/Thermostat%20Related%20Behavior.PDF
5. Guidehouse, "Residential Wi-Fi and Programmable Thermostat Impacts; RES24 Final Report". Prepared for Massachusetts Program Administrators. September 29, 2021.
   Available from: https://ma-eeac.org/wp-content/uploads/MARES24-Final-Report-2021-09-29.pdf

6. Programmable thermostat savings for the cooling season taken from the ENERGY STAR® website's calculator "Life Cycle Cost Estimate for ENERGY STAR Qualified Programmable Thermostat(s)".
   Available from: https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.energystar.gov%2Fia%2Fpartners%2Fpromotions%2Fcool_change%2Fdownloads%2FCalculatorProgrammableThermostat.xls&wdOrigin=BROWSELINK

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
1	12/31/2015
1-17-3	12/31/2016
2-17-1	2/10/2017
3-24-4	3/29/2024

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LIGHTING

CONNECTED LIGHTING

Measure Description

This measure covers the installation of connected lighting products (e.g., "smart" bulbs) and controls (e.g., "smart" switches and hub-controlled lighting systems) in residential interior and exterior spaces. Connected lighting control systems are LED-based lighting systems with integrated sensors and controllers that are networked (either wired or wireless), enabling lighting equipment within the system to communicate and exchange data with other devices and be controlled remotely. These systems save energy and peak demand by reducing lighting operating hours and dimming lamps.

The method prescribed herein must be applied separately for equipment installed in conditioned interior spaces, unconditioned interior spaces, and exterior/unknown locations to accurately reflect peak demand impacts and interactivity with HVAC systems.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{W_{ctrl}}{1{,}000}\right) \times hrs \times ESF \times (1 + HVAC_c)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{W_{ctrl}}{1{,}000}\right) \times ESF \times (1 + HVAC_d) \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = \left(\frac{W_{ctrl}}{1{,}000}\right) \times hrs \times ESF \times HVAC_{ff}$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
W_{ctrl}	= Total wattage of controlled lighting (Watts)
hrs	= Annual lighting operating hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_{ff}$	= HVAC interaction factor for annual fossil fuel consumption
ESF	= Energy savings factor
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
W_{ctrl}		From application. Lighting in conditioned interior spaces, unconditioned interior spaces, and exterior/unknown locations shall be treated independently.
hrs		From application. If unknown, see Operating Hours section below.
$HVAC_c$	Unconditioned, Exterior, and Unknown Locations: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. If unknown, assume Single Family Home building type, new vintage, and AC with Fuel heat HVAC type. See Appendix D.
$HVAC_d$	Unconditioned, Exterior, and Unknown Locations: 0	HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. If unknown, assume Single Family Home building type, new vintage, and AC with Fuel heat HVAC type. See Appendix D.
$HVAC_{ff}$	Unconditioned, Exterior, and Unknown Locations: 0	HVAC interaction factor for annual fossil fuel energy consumption (MMBtu/kWh). Vintage and HVAC type weighted average by city. If unknown, assume Single Family Home building type, new vintage, and AC with Fuel heat HVAC type. See Appendix D.
ESF	0.29	Energy Savings Forecast of Solid State Lighting in General Illumination Applications.[62]
CF	Interior: 0.13 Exterior and Unknown Locations: 0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor for lighting in interior spaces is 0.13.[63] For exterior and unknown installation locations, the prescribed value for the coincidence factor is 0.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is LED lighting without a connected lighting system.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is LED lighting with a connected lighting system that allows for remote user control of lighting, lighting brightness, and lighting schedules.[64]

[62] Navigant Consulting, U.S. DOE, Energy Savings Forecast of Solid State Lighting in General Illumination Applications, December 2019, Page 112, Table F.4.
[63] NMR Group Inc., Northeast Residential Lighting Hour-of Use Study, May 5, 2014, Page XVII, Table ES-7
[64] Navigant Consulting. Department of Energy Solid-State Lighting Program. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. December 2019, Page 105 Table F.3.

Operating Hours

Look up operating hours from the table below, based on lamp location and city. See details below for derivation of operating hours. "Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. "Unknown" is not a valid selection for direct install programs.

City	Interior	Exterior	Unknown
Albany	986	2,081	1,022
Binghamton	986	2,081	1,022
Buffalo	986	2,081	1,022
Massena	986	2,081	1,022
NYC	1,752	2,117	1,752
Poughkeepsie	986	2,081	1,022
Syracuse	986	2,081	1,022

NYS cities other than NYC, Interior

Hours of operation for interior lighting is estimated to be 2.7 operating hours per day or 986 (2.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[65]

NYS cities other than NYC, Exterior

Hours of operation for exterior lighting is estimated to be 5.7 operating hours per day or 2,081 (5.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[66]

NYS cities other than NYC, Unknown

Hours of operation for lighting installed in an unknown location is estimated to be 2.8 operating hours per day or 1,022 (2.8 x 365) hours per year. This value is a weighted average of interior and exterior lighting hours derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[67]

NYC, Interior

[65] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-5: HOU by Area Adjusted for Snapback, Table 3-2: Sample Sizes, Overall HOU Estimates by Area and Room, and hierarchical model as described in section 2.6.3 (pg. 22). HOU referenced is a weighted average of interior room types for UNY and is Snapback Adjusted.

[66] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-5: HOU by Area Adjusted for Snapback and hierarchical model as described in section 2.6.3 (pg. 22). HOU referenced is the value for Exterior for UNY and is Snapback Adjusted.

[67] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-5: HOU by Area Adjusted for Snapback and hierarchical model as described in section 2.6.3 (pg. 22). HOU referenced is the value for Household for UNY, which is a weighted average of all room types and is Snapback Adjusted.

Hours of operation for exterior lighting is estimated to be 4.8 operating hours per day or 1,752 (4.8 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York City and Westchester County.[68]

NYC, Exterior
Hours of operation for exterior lighting is estimated to be 4.4 operating hours per day or 1,606 (4.4 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York City and Westchester County.[69]

NYC, Unknown
Hours of operation for lighting installed in an unknown location is estimated to be 4.8 operating hours per day or 1,752 (4.8 x 365) hours per year. This value is a weighted average of interior and exterior lighting hours derived from on-site lighting inventories of homes in New York City and Westchester County.[70]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction in lighting power increases space heating requirements in conditioned spaces. Interactive HVAC impacts are addressed in prescribed energy savings calculation methodology.

Ancillary Electric Savings Impacts

Reduction in lighting power decreases cooling requirements in conditioned spaces. Interactive HVAC impacts are addressed in prescribed energy savings calculation methodology.

References

1. Navigant Consulting. Department of Energy Solid-State Lighting Program. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. December 2019.
   Available from: https://www.energy.gov/sites/default/files/2020/02/f72/2019_ssl-energy-savings-forecast.pdf
2. NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014.
   Available from: https://neep.org/sites/default/files/resources/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf

[68] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-6: HOU by Area Adjusted for Snapback and Table 3-2: Sample Sizes, Overall HOU Estimates by Area and Room. HOU referenced is a weighted average for interior room types for DNY and is Snapback Adjusted.
[69] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-6: HOU by Area Adjusted for Snapback. HOU referenced is the value for Exterior for DNY and is Snapback Adjusted.
[70] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-6: HOU by Area Adjusted for Snapback. HOU referenced is the value for Household for DNY, which is a weighted average of all room types and is Snapback Adjusted. The study's sample size included far more interior to exterior lights, thus a weighted distribution heavily favors the interior lighting hours.

Record of Revision

Record of Revision Number	Issue Date
6-22-6	9/2/2022
3-24-5	3/29/2024

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APPLIANCE

OVEN, STEAMER, FRYER, AND GRIDDLE

Measure Description

This measure covers the installation of ENERGY STAR® qualified commercial kitchen equipment that meet the descriptions below. Unless otherwise noted, presented baseline, compliance, and default values are determined from the ENERGY STAR® Commercial Food Service Equipment Calculator.[71]

- Convection Ovens[72] - This measure includes gas and electric commercial convection ovens. A convection oven forces hot dry air over the surface of a food product. A full-size convection oven can accommodate standard full-size sheet pans measuring 18 x 26 x 1 inch. A half-size convection oven can accommodate half-size sheet pans measuring 18 x 13 x 1 inch. Though not eligible for ENERGY STAR® qualification, this measure includes half-size gas convection ovens. Half-size gas convection ovens must have an idle rate of 8,500 BTU/h or less, per the assumed efficiency of qualified equipment by Pacific Gas & Electric workpaper.[73]
- Rack Ovens[74] - This measure includes gas commercial rack ovens. A rack oven is a high-capacity oven in which a rack is wheeled into the oven and can be rotated during the baking process. Rack ovens range in capacity from mini rack ovens to quadruple rack ovens. Single and double rack ovens are included in this measure.
- Steamers[75] - This measure includes gas and electric commercial steamers, also known as compartment steamers. A steamer is a device that contains one or more food steaming compartments in which the energy in the steam is transferred to the food by direct contact. To calculate the savings for this measure, the number of pans must be known. Countertop, wall-mounted, and floor models mounted on a stand, pedestal, or cabinet-style base are included. Commercial steamer microwave ovens are not included in this measure.
- Fryers[76] - This measure includes gas and electric commercial deep-fat fryers. A deep-fat fryer is an appliance in which oils are placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid rather than by the bottom of the vessel. Depending on the fryer type, heat is delivered to the cooking fluid by means of an immersed electric element or band-wrapped vessel (electric fryers), or by heat transfer from gas burners through either the walls of the fryer or through tubes passing through the cooking fluid (gas fryers). Standard fryers and large vat fryers are included in this measure.

[71] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018).
[72] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 3.0., April 2022.
[73] PG&E Work Paper PGECOFST101 Revision 6, Table 12, pg. 18.
[74] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 3.0, April 2022.
[75] ENERGY STAR® Program Requirements for Commercial Steam Cookers, Eligibility Criteria Version 1.2, August 2003.
[76] ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 3.0. October 2016.

- Griddles[77] - This measure includes single-sided gas and electric commercial griddles. A single-sided commercial griddle is a commercial appliance designed for cooking food in oil or its own juices by direct contact with either a flat, smooth, hot surface or a hot channeled cooking surface where plate temperature is thermostatically controlled. To calculate the energy savings in this measure, the griddle dimensions must be known. This measure does not include double-sided gas or electric commercial griddles.
- Gas Conveyor Ovens - Though not eligible for ENERGY STAR® qualification, this measure additionally covers the installation of energy-efficient gas conveyor ovens. Conveyor ovens cook food by carrying it on a moving belt through a heated chamber. Qualifying conveyor ovens have baking efficiencies greater than or equal to 42% and idle energy rates less than or equal to 57,000 BTU/h, per assumed efficiency of qualified equipment by Pacific Gas and Electric workpaper.[78]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Equipment Only)

$$\Delta kWh = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle} + \Delta BTU_{cooking}\right)}{3{,}412}$$

Summer Peak Coincident Demand Savings (Electric Equipment Only)

$$\Delta kW = \frac{\Delta kWh}{(days \times hrs)} \times CF$$

Annual Fossil Fuel Energy Savings (Fossil Fuel Equipment Only)

$$\Delta MMBtu = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle} + \Delta BTU_{cooking}\right)}{1{,}000{,}000}$$

where:

$$\Delta BTU_{preheat} = N_{preheat} \times \left(BTU_{preheat,baseline} - BTU_{preheat,ee}\right)$$

$$\Delta BTU_{idle} = BTU/h_{idle,baseline} \times \left[hrs - N_{preheat} \times hrs_{preheat} - \left(\frac{lbs}{(lbs/hr)_{baseline}}\right)\right] - BTU/h_{idle,ee} \times \left[hrs - N_{preheat} \times hrs_{preheat} - \left(\frac{lbs}{(lbs/hr)_{ee}}\right)\right]$$

$$\Delta BTU_{cooking} = lbs \times Q_{food} \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right)$$

[77] ENERGY STAR® Program Requirements for Commercial Griddles, Eligibility Criteria Version 1.2, January 2011.
[78] PG&E Work Paper PGECOFST117 Revision 5, Table 9, pg. 11-12, where 1 pizza equals 0.76 lbs.

NOTE: $\Delta BTU_{preheat}$, ΔBTU_{idle}, and $\Delta BTU_{cooking}$ terms can be calculated per the equations above using either actual qualifying equipment specs or default values as defined in the Common Variables, Baseline Efficiencies, Compliance Efficiency and Operating Hours sections below, or looked up from the Default Values table below.

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta MMBtu$ = Annual fossil fuel energy savings
$\Delta BTU_{preheat}$ = Daily preheat energy savings
ΔBTU_{idle} = Daily idle energy savings
$\Delta BTU_{cooking}$ = Daily cooking energy savings
units = Number of measures installed under the program
days = Operating days per year
hrs = Daily operating hours
$_{baseline}$ = Characteristic of baseline condition
$_{ee}$ = Characteristic of energy efficient condition
$BTU_{preheat}$ = Equipment preheat energy (BTU)
$N_{preheat}$ = Number of preheats per day
$hrs_{preheat}$ = Preheat duration (hours)
BTU/h_{idle} = Equipment idle energy rate (BTU/h)
(lbs/hr) = Equipment production capacity (lbs/hr)
lbs = Total daily food production
Q_{food} = Heat to food (BTU/lb)
Eff = Equipment convection/steam mode cooking efficiency, as defined by ENERGY STAR® program requirements or relevant standard for each equipment type
CF = Coincidence factor
3,412 = Conversion factor, one kW equals 3,412 BTU/h
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta BTU_{preheat}$		Calculate based on calculations above or look up in the Default Values table below.
ΔBTU_{idle}		Calculate based on calculations above or look up in the Default Values table below.
$\Delta BTU_{cooking}$		Calculate based on calculations above or look up in the Default Values table below.
days		From the application or look up based on facility type in the Operating Hours section below.
hrs		From the application or look up based on the facility type in the Operating Hours section below.
$N_{preheat}$	1	Pacific Gas and Electric.[79]

[79] Shared assumption from all PG&E Work Papers referenced in this measure.

Variable	Value	Notes
$BTU_{preheat,baseline}$		Look up based on qualifying equipment type in the Baseline Efficiencies section below.
$BTU_{preheat,ee}$		From the application or look up based on the qualifying equipment type in the Compliance Efficiency section below.
$BTU/h_{idle,baseline}$		Look up based on qualifying equipment type in the Baseline Efficiencies section below.
$BTU/h_{idle,ee}$		From the application or look up based on the qualifying equipment type in the Compliance Efficiency section below.
$hrs_{preheat}$		Look up based on qualifying equipment type in the Common Variables table below.
$(lbs/hr)_{baseline}$		Look up based on qualifying equipment type in the Baseline Efficiencies section below.
$(lbs/hr)_{ee}$		From the application or look up based on the qualifying equipment type in the Compliance Efficiency section below
Lbs		From the application or look up based on the qualifying equipment type in the Common Variables table below.
Q_{food}		Look up based on qualifying equipment type in the Common Variables table below.
$Eff_{baseline}$		Look up based on qualifying equipment type in the Baseline Efficiencies section below.
Eff_{ee}		From the application or look up based on the qualifying equipment type in the Compliance Efficiency section below.
CF	0.9	

Default Values

The table below contains values and simplified calculations for $\Delta BTU_{preheat}$, $\Delta BTU_{idle,}$ and $\Delta BTU_{cooking}$ terms that may be used in the formulation of estimated savings in lieu of utilizing the calculations prescribed above for these terms. These values were established by performing those calculations using assumed values from the Common Variables, Baseline Efficiencies, and Compliance Efficiency sections below. Note that the values below assume baseline equipment product class, fuel type, and capacity equivalent to the efficient case. equivalent replacement regarding equipment capacity, fuel type, and product class.

Equipment	$\Delta BTU_{preheat}$	ΔBTU_{idle}	$\Delta BTU_{cooking}$
Convection Oven, Electric, Full-Size	580	683 x hrs - 663	2,317
Convection Oven, Electric, Half-Size	649	-619	0
Convection Oven, Gas, Full-Size	3,647	2,500 x hrs - 3,061	3,327
Convection Oven, Gas, Half-Size	2,625	3,500 x hrs - 11,842	3,968
Conveyor Oven, Gas	8,662	13,000 x hrs - 48,566	30,844
Rack Oven, Gas, Double Rack	24,251	0	0
Rack Oven, Gas, Single Rack	12,233	0	0
Steamer, Electric	4,197	772	5,783
Steamer, Gas	8,539	1,487	7,439
Fryer, Electric, Standard	648	682 x hrs - 1,928	3,863
Fryer, Electric, Large Vat	1,194	-512	8,599
Fryer, Gas	6,331	1,900 x hrs - 5,678	18,321
Fryer, Gas, Large Vat	5,000	2,400 x hrs - 4,357	33,097
Griddle, Electric	1,138 x griddle area*	273 x griddle area* x hrs + 68 x griddle area* - 7,042	5,220
Griddle, Gas	1,000 x griddle area*	850 x griddle area* x hrs + 213 x griddle area* - 48,600	23,438

*Griddle area in square feet

Common Variables[80]

Equipment	Value		
	$hrs_{preheat}$	lbs	Q_{food} (BTU/lb)
Convection Oven, Electric, Full-Size	0.14[81]	100	250
Convection Oven, Electric, Half-Size	0.14[82]	100	250
Convection Oven, Gas, Full-Size	0.14[83]	100	250
Convection Oven, Gas, Half-Size	0.18[84]	100	250
Conveyor Oven, Gas	0.25[85]	190	250
Rack Oven, Gas, Double Rack	0.33[86]	1,200[87]	235
Rack Oven, Gas, Single Rack	0.33[88]	600	235

[80] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018), unless otherwise noted.
[81] California TF, Work Paper SWFS001-02, pg. 7.
[82] California TF, Work Paper SWFS001-02, pg. 7.
[83] California TF, Work Paper SWFS001-02, pg. 11.
[84] California TF, Work Paper SWFS001-02, pg. 18.
[85] California TF, Work Paper SWFS008-01, pg. 7, where 1 pizza equals 0.76 lbs.
[86] California TF, Work Paper SWFS014-02, pg. 7.
[87] Ibid.
[88] Ibid, pg. 8.

Equipment	Value		
	$hrs_{preheat}$	lbs	Q_{food} (BTU/lb)
Steamer, Electric	0.22[89]	100	105
Steamer, Gas	0.22[90]	100	105
Fryer, Electric, Standard	0.14[91]	150	570
Fryer, Electric, Large Vat	0.14[92]	150	570
Fryer, Gas, Standard	0.23[93]	150	570
Fryer, Gas, Large Vat	0.23[94]	150	570
Griddle, Electric	0.25[95]	100	475
Griddle, Gas	0.25[96]	100	475

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[97]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is food service equipment as defined in the Measure Description above with operating characteristics per the table below. Values are as reported from the referenced ENERGY STAR® Commercial Food Service Equipment Calculator unless otherwise noted.[98] It is important to note that these calculations assume an equivalent replacement regarding equipment capacity, fuel type, and product class.

Equipment	$BTU_{preheat,baseline}$ (BTU)	$BTUhi_{dle,baseline}$ (BTU/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$
Convection Oven, Electric, Full-Size	5,323[99]	5,459[100]	90	0.71[101]
Convection Oven, Electric, Half-Size	3,037[102]	3,412[103]	45	0.71[104]

[89] California TF, Work Paper SWFS005-02, pg. 9.
[90] California TF, Work Paper SWFS005-02, pg. 13.
[91] California TF, Work Paper SWFS011-03, pg, 8.
[92] Ibid.
[93] California TF, Work Paper SWFS011-03, pg, 12.
[94] Ibid.
[95] California TF Work Paper SWFS004 Revision 1, pg. 7.
[96] California TF Work Paper SWFS004 Revision 1, pg. 10.
[97] Shared assumption from all PG&E Work Papers referenced in this measure.
[98] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018).
[99] California TF, Work Paper SWFS001-02, pg. 7.
[100] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens Eligibility Criteria Version 2.2 via NYS Appliances Standards
[101] Ibid.
[102] California TF, Work Paper SWFS001-02, pg. 7.
[103] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens Eligibility Criteria Version 2.2 via NYS Appliances Standards
[104] Ibid.

Equipment	$BTU_{preheat,baseline}$ (BTU)	$BTUhi_{dle,baseline}$ (BTU/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$
Convection Oven, Gas, Full-Size	13,096[105]	12,000[106]	83	0.46[107]
Convection Oven, Gas, Half-Size[108]	6,000	12,000	45	0.42
Conveyor Oven, Gas[109]	48,662	70,000	114	0.33
Rack Oven, Gas, Double Rack	90,009[110]	30,000[111]	250	0.52[112]
Rack Oven, Gas, Single Rack	54,817[113]	25,000[114]	130	0.48[115]
Steamer, Electric	5,186[116]	455 x no. pans[117]	23.3 x no. pans	0.50[118]
Steamer, Gas	18,833[119]	2,100 x no. pans[120]	23.3 x no. pans	0.38[121]
Fryer, Electric, Standard	5,971[122]	3,412[123]	65	0.80[124]
Fryer, Electric, Large Vat	10,577[125]	3,753[126]	100	0.80[127]
Fryer, Gas, Stand-ard	16,609[128]	9,000[129]	60	0.50[130]

[105] California TF, Work Paper SWFS001-02, pg. 11.
[106] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens Eligibility Criteria Version 2.2 via NYS Appliances Standards
[107] Ibid.
[108] California TF, Work Paper SWFS001-02, pg. 11.
[109] California TF, Work Paper SWFS008-02, pg. 7, where 1 pizza equals 0.76 lbs.
[110] California TF, Work Paper SWFS014-02, pg. 8.
[111] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens Eligibility Criteria Version 2.2 via NYS Appliances Standards
[112] Ibid.
[113] California TF, Work Paper SWFS014-02, pg. 7.
[114] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens Eligibility Criteria Version 2.2 via NYS Appliances Standards
[115] Ibid.
[116] California TF, Work Paper SWFS005-02, pg. 9.
[117] ENERGY STAR® Program Requirements for Commercial Steam Cookers V1.2 via NYS Appliances Standards
[118] Ibid.
[119] California TF, Work Paper SWFS005-02, pg. 13.
[120]ENERGY STAR® Program Requirements for Commercial Steam Cookers V1.2 via NYS Appliances Standards
[121] Ibid.
[122] California TF, Work Paper SWFS011-02, pg. 8.
[123] ENERGY STAR ® Program Requirements for Commercial Fryers V2.0
[124] Ibid.
[125] California TF, Work Paper SWFS011-02, pg. 8.
[126] ENERGY STAR ® Program Requirements for Commercial Fryers V2.0
[127] Ibid.
[128] California TF, Work Paper SWFS011-02, pg. 11.
[129] ENERGY STAR ® Program Requirements for Commercial Fryers V2.0
[130] Ibid.

Equipment	$BTU_{preheat,baseline}$ (BTU)	$BTUhi_{dle,baseline}$ (BTU/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$
Fryer, Gas, Large Vat	27,000[131]	12,000[132]	100	0.50[133]
Griddle, Electric	2,275 x griddle area*[134]	1,365 x griddle area*	5.83 x griddle area*	0.65
Griddle, Gas	3,500 x griddle area*[135]	3,500 x griddle area*	4.17 x griddle area*	0.32

*Griddle area in square feet

Compliance Efficiency from which Incentives are Calculated

The compliance condition is ENERGY STAR® food service equipment meeting the minimum performance specifications listed in the table below. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the table below. Preheat energy and all values are reported from referenced California TF workpaper sources.

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	$(lbs/hr)_{ee}$	Eff_{ee}
Convection Oven, Electric, Full-Size	4,743[136]	4,776[137]	90	0.76[138]
Convection Oven, Electric, Half-Size	2,388[139]	3,412[140]	49	0.71[141]
Convection Oven, Gas, Full-Size	9,449[142]	9,500[143]	86	0.49[144]
Convection Oven, Gas, Half-Size[145]	3,375	8,500	55	0.45
Conveyor Oven, Gas[146]	40,000	57,000	167	0.42

[131] California TF, Work Paper SWFS011-02, pg. 11.
[132] ENERGY STAR ® Program Requirements for Commercial Fryers V2.0
[133] Ibid.
[134] California TF, Work Paper SWFS004-01, pg. 7.
[135] California TF, Work Paper SWFS004-01, pg. 7.
[136] California TF, Work Paper SWFS001-02, pg. 7.
[137] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 3.0
[138] Ibid.
[139] California TF, Work Paper SWFS001-02, pg. 7.
[140] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 3.0
[141] Ibid.
[142] California TF, Work Paper SWFS001-02, pg. 11.
[143] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 3.0
[144] Ibid.
[145] California TF, Work Paper SWFS001-02, pg. 11.
[146] California TF, Work Paper SWFS008-02, pg. 7, where 1 pizza equals 0.76 lbs.

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	$(lbs/hr)_{ee}$	Eff_{ee}
Rack Oven, Gas, Double Rack	65,758[147]	30,000[148]	250	0.52[149]
Rack Oven, Gas, Single Rack	42,584[150]	25,000[151]	130	0.48[152]
Steamer, Electric	989[153]	455 x no. pans[154]	16.7 x no. pans	0.69[155]
Steamer, Gas	10,294[156]	2,100 x no. pans[157]	20.0 x no. pans	0.52[158]
Fryer, Electric, Standard	5,323[159]	2,730[160]	70	0.83[161]
Fryer, Electric, Large Vat	9,383[162]	3,753[163]	110	0.87[164]
Fryer, Gas, Standard	10,278[165]	7,100[166]	65	0.56[167]
Fryer, Gas, Large Vat	22,000[168]	9,600[169]	110	0.62[170]
Griddle, Electric	1,137 x griddle area*[171]	1,092 x griddle area*	6.67 x griddle area*	0.70
Griddle, Gas	2,500 x griddle area*[172]	2,650 x griddle area*	7.5 x griddle area*	0.38

* Griddle area in square feet

Operating Hours

[147] California TF, Work Paper SWFS014-02, pg. 8.
[148] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 3.0
[149] Ibid.
[150] California TF, Work Paper SWFS014-02, pg. 8.
[151] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 3.0
[152] Ibid.
[153] California TF, Work Paper SWFS005-02, pg. 9.
[154] ENERGY STAR® Program Requirements for Commercial Steam Cookers V1.2
[155] Con Edison 2023 program minimum qualifying specifications
[156] California TF, Work Paper SWFS005-02, pg. 13.
[157] ENERGY STAR® Program Requirements for Commercial Steam Cookers V1.2
[158] Con Edison 2023 program minimum qualifying specifications
[159] California TF, Work Paper SWFS011-02, pg. 8.
[160] ENERGY STAR ® Program Requirements for Commercial Fryers V3.0
[161] Ibid.
[162] California TF, Work Paper SWFS011-02, pg. 8.
[163] ENERGY STAR ® Program Requirements for Commercial Fryers V3.0
[164] Ibid.
[165] California TF, Work Paper SWFS011-02, pg. 11.
[166] Con Edison 2023 program minimum qualifying specifications
[167] Ibid.
[168] California TF, Work Paper SWFS011-02, pg. 11.
[169] Con Edison 2023 program minimum qualifying specifications
[170] Ibid.
[171] California TF Work Paper SWFS004-01, pg. 7.
[172] California TF Work Paper SWFS004 -01, pg. 10.

Equipment operating hours per day and days per year shall be taken from the application if known. Default operating hours per day and days per year are provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[173]

Facility Type	hours/day	days/year
Community College	11	283
Fast Food Restaurant	14	363
Full-Service Restaurant	12	321
Grocery	12	365
Hospital	11	365
Hotel	20	365
Miscellaneous	9	325
Motel	20	365
Primary School	5	180
Secondary School	8	180
Office	12	250
University	11	283

Example Calculation *(Not to be used as default)*

A full-size electric convection oven with 90 lb/hr capacity, 3,470 $BTU_{preheat}$, 4,400 BTU/h_{idle}, and 76% efficiency is installed in a restaurant in NYC, which operates for 12 hours a day for 320 days per year. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle} + \Delta BTU_{cooking}\right)}{3{,}412}$$

$$\Delta kW = \frac{\Delta kWh}{(days \times hrs)} \times CF$$

where:

$$\Delta BTU_{preheat} = N_{preheat} \times \left(BTU_{preheat,baseline} - BTU_{preheat,ee}\right)$$

$$\Delta BTU_{idle} = BTU/h_{idle,baseline} \times \left[hrs - N_{preheat} \times hrs_{preheat} - \left(\frac{lbs}{(lbs/hr)_{baseline}}\right)\right] - BTU/h_{idle,ee} \times \left[hrs - N_{preheat} \times hrs_{preheat} - \left(\frac{lbs}{(lbs/hr)_{ee}}\right)\right]$$

$$\Delta BTU_{cooking} = lbs \times Q_{food} \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right)$$

[173] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E.

units = 1, from application
days = 320 days/year, from application
$N_{preheat}$ = 1, from Summary of Variables and Data Sources
$BTU_{preheat,baseline}$ = 5,323 BTU, from Baseline Efficiencies from which Energy Savings are calculated
$BTU_{preheat,ee}$ = 3,470 BTU, from application
$BTU/h_{idle,baseline}$ = 5,459 BTU, from Baseline Efficiencies from which Energy Savings are calculated
$BTU/h_{idle,ee}$ = 4,400 BTU, from application
$Hrs_{preheat}$ = 0.14, from Common Variables
Hrs = 12 hours/day, from application
Lbs = 100 lbs, from Common Variables
$(Lbs/hr)_{baseline}$ = 90 lbs/hr, from Baseline Efficiencies from which Energy Savings are calculated
(lbs/hr)ee = 90, from application
Q_{food} = 250 BTU/lb, from Common Variables
$Eff_{baseline}$ = 0.71, from Baseline Efficiencies from which Energy Savings are calculated
Eff_{ee} = 0.76, from application
CF = 0.9, from Summary of Variables and Data Sources

$$\Delta BTU_{preheat} = 1 \times (5{,}323 - 3{,}470) = 1{,}853$$

$$\Delta BTU_{idle} = 5{,}459 \times \left[12 - 1 \times 0.14 - \left(\frac{100}{90}\right)\right] - 4{,}400 \times \left[12 - 1 \times 0.14 - \left(\frac{100}{90}\right)\right] = 11{,}383.07$$

$$\Delta BTU_{cooking} = 100 \times 250 \times \left(\frac{1}{0.71} - \frac{1}{0.76}\right) = 2{,}316.53$$

$$\Delta kWh = 1 \times 320 \times \frac{(1{,}853 + 11{,}383.07 + 2{,}316.53)}{3{,}412} = 1{,}458.62\ kWh$$

$$\Delta kW = \frac{1{,}458.62}{(320 \times 12)} \times 0.9 = 0.34\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

Ancillary Electric Savings Impacts

More efficient food service equipment rejects less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

References

1. ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 3.0, January 2023.
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8. California Technical Forum workpaper, Commercial Rack Oven, SWFS014-02, December 2019.
9. California Technical Forum workpaper, Commercial Steam Cooker, SWFS005-02, December 2019.
10. California Technical Forum workpaper, Commercial Fryer, SWFS011-03, June 2021.
11. California Technical Forum workpaper, Commercial Griddle, SWFS004-1, October 2018.
12. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014.

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14. NYSERDA NY State Appliance and Equipment Current Standards.
Available from: https://www.nyserda.ny.gov/All-Programs/New-York-State-Appliance-and-Equipment-Efficiency-Standards/Current-Standards

Record of Revision

Record of Revision Number	Issue Date
3-18-18	3/29/2018
3-20-4	3/30/2020
12-21-11	1/28/2022
11-23-4	11/30/2023
3-24-6	3/29/2024

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COMPRESSED AIR

COMPRESSED AIR - LOW PRESSURE DROP FILTERS

Measure Description

This measure applies to the installation of low pressure drop filters on existing compressed air systems to remove contaminants, such as dirt, oil, water, and other particulates, from the compressed air stream The term 'low pressure drop' indicates that the filter causes minimal reduction in air pressure as the air flows through it, which is important for maintaining efficient operation of pneumatic equipment. Typical coalescing oil filters operate with a pressure drop in the range of 2 to 10 pounds-per-square-inch differential (psid). In contrast, a low pressure drop filter exhibits close to a 0.5 psid pressure drop, increasing over time to 3 psid at which point filter replacement is recommended. The reduced pressure drop allows the compressed air system to operate more efficiently.

For multi-compressor and multi-filter systems, terms specified in the method below shall be treated as aggregate values across the entire system. Pressure drop reduction (Δpsid) shall reflect the total pressure drop reduction across all replaced filters (e.g., applying the default value of 4 psid per filter, replacement of 3 filters would result in a total pressure drop reduction of 12 psi). Similarly, compressed air system horsepower (hp_{comp}) shall reflect the total horsepower of all compressor motors in the system and total system efficiency (Eff) shall reflect the horsepower weighted average of all compressor motor efficiencies identified on the application or via the Motor Efficiency lookup table below.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings[174]

Annual Electric Energy Savings

$$\Delta kWh = 0.746 \times LF \times (ESF/psid) \times \Delta psid \times hrs \times \sum \frac{hp_{comp}}{Eff}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = 0.746 \times LF \times (ESF/psid) \times \Delta psid \times CF \times \sum \frac{hp_{comp}}{Eff}$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh = Annual electric energy savings

[174] The use of the sigma operator is intended to address multi-compressor systems. In those cases, the sum of each compressor's hp rating divided by its efficiency shall be input. For single compressor systems, the sigma operator can be ignored.

ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fossil fuel energy savings
LF = Load Factor of the compressed air system
hrs = Motor/compressor runtime (hours)
(ESF/psid) = Percent savings per psid pressure drop reduction
Δpsid = Reduction in pressure drop resulting from low pressure drop filters, in psid
hp_{comp} = Horsepower of each air compressor motor
Eff = Efficiency of each air compressor motor
0.746 = Conversion factor (kW/hp), 746 watts equals one horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
LF		From application. If unknown use 0.92 as default value.[175]
(ESF/psid)	0.005	Rule of thumb for compressed air systems indicates a 0.5% reduction in energy requirement per 1 psi reduction in compressor outlet pressure.[176]
Δpsid		From application. If unknown use 4 psid per replaced filter as a default value.[177]
hrs		From application. If unknown, lookup in Operating Hours section below based on facility type.
hp_{comp}		From application.
Eff		From application. If unknown lookup based on horsepower, RPM, and TEFC/ODP in Motor Efficiency table below.
CF	Single shift: 0 Two shift, three shift or continuous operation: 0.8	Based on facility operation schedule.

Motor Efficiency[178]

HP	Open Drip Proof			Totally Enclosed Fan Cooled		
RPM	1200	1800	3600	1200	1800	3600
1	0.825	0.855	0.770	0.825	0.855	0.770
1.5	0.865	0.865	0.840	0.875	0.865	0.840
2	0.875	0.865	0.855	0.885	0.865	0.855
3	0.885	0.895	0.855	0.895	0.895	0.865
5	0.895	0.895	0.865	0.895	0.895	0.885
7.5	0.902	0.910	0.885	0.910	0.917	0.895
10	0.917	0.917	0.895	0.910	0.917	0.902
15	0.917	0.930	0.902	0.917	0.924	0.910

[175] Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012. Table 6: Load Factor by nameplate hp and end use load.
[176] Compressed Air Best Practices, Optimizing Pneumatic Systems for Extra Savings
[177] Ibid.
[178] Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012. Table 3: NEMA premium efficient motor standards.

HP	Open Drip Proof			Totally Enclosed Fan Cooled		
RPM	1200	1800	3600	1200	1800	3600
20	0.924	0.930	0.910	0.917	0.930	0.910
25	0.930	0.936	0.917	0.930	0.936	0.917
30	0.936	0.941	0.917	0.930	0.936	0.917
40	0.941	0.941	0.924	0.941	0.941	0.924
50	0.941	0.945	0.930	0.941	0.945	0.930
60	0.945	0.950	0.936	0.945	0.950	0.936
75	0.945	0.950	0.936	0.945	0.954	0.936
100	0.950	0.954	0.936	0.950	0.954	0.941
125	0.950	0.954	0.941	0.950	0.954	0.950
150	0.954	0.958	0.941	0.958	0.958	0.950
200	0.954	0.958	0.950	0.958	0.962	0.954
250	0.958	0.958	0.953	0.955	0.955	0.958
300	0.958	0.958	0.955	0.955	0.958	0.958
350	0.958	0.958	0.955	0.955	0.958	0.958
400	0.958	0.958	0.958	0.955	0.958	0.958
450	0.958	0.960	0.960	0.955	0.958	0.958
500	0.958	0.960	0.960	0.955	0.960	0.958

Coincidence Factor (CF)

The prescribed value for the coincidence factor is based on facility operating hours. Apply a coincidence factor of 0.8 for facilities operating two shift, three shift, or continuous operating schedules. Coincidence factor is 0.0 for facilities operating single shift schedules.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a compressed air system with a standard coalescing filter.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a compressed air system with a low pressure drop filter. The initial clean and dry pressure differential of the filter must be <1 psid.

Operating Hours

Operating hours shall come from application and reflect annual motor/compressor run hours. For industrial processes, the default hours based on number of shifts provided in the table below may be used. The values in the table below shall only be used for compressed air applications where the system is in continuous use during facility operation for industrial processes. Otherwise, hours of operation must be identified on the application.

Shift	Hours
Single Shift 7AM – 3 PM, weekdays, minus 10 federal holidays and three 8-hour shifts of scheduled down time	1,976

Shift	Hours
Two Shifts 7AM – 11 PM, weekdays, minus 10 federal holidays and six 8-hour shifts of scheduled down time	3,952
Three Shifts 24 hours per day, weekdays, minus 10 federal holidays and nine 8-hour shifts of scheduled down time	5,928
Four Shifts or Continual Operation 24 hours per day, 7 days a week minus 10 federal holidays and 55 8-hour shifts of scheduled down time	8,320

Example Calculation *(Not to be used as default)*

Low pressure drop filters are installed on a 200 hp compressed air system in a two-shift industrial process facility. The average compressed air system motor efficiency is 94%, the load factor is 90% and it operates 4,000 hours per year. As a result of filter replacement, the measured pressure drop across the filters decreased by 5 psi. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = 0.746 \times LF \times (ESF/psid) \times \Delta psid \times hrs \times \sum \frac{hp_{comp}}{Eff}$$

$$\Delta kW = 0.746 \times LF \times (ESF/psid) \times \Delta psid \times CF \times \sum \frac{hp_{comp}}{Eff}$$

LF = 0.90, from application
(ESF/psid) = 0.005, from Summary of Variables and Data Sources
Δpsid = 5, from application
hrs = 4,000, from application
hp_{comp} = 200 hp, from application.
Eff = 0.94 From application
CF = 0.8, from Summary of Variables and Data Sources based on operating hours

$$kWh = 0.746 \times 0.90 \times 0.005 \times 5 \times 4{,}000 \times \sum \frac{200}{0.94} = 14{,}285.11\ kWh$$

$$\Delta kW = 0.746 \times 0.90 \times 0.005 \times 5 \times 0.8 \times \sum \frac{200}{0.94} = 2.86\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

References

1. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.
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Record of Revisions

Record of Revision Number	Issue Date
7-20-11	7/31/2020
6-22-8	9/2/2022
3-24-7	3/29/2024

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

CHILLER - AIR AND WATER COOLED

Measure Description

This measure covers the installation of high efficiency constant and variable speed electric air-cooled and water-cooled chillers in commercial and multifamily buildings with built-up HVAC systems. This measure is applicable in both replacement and new construction scenarios.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times (IPLV_{baseline} - IPLV_{ee}) \times EFLH_{cooling}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times (FL_{baseline} - FL_{ee}) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of chillers installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition
IPLV	= Part load chiller efficiency, expressed as Integrated Part-Load Value (in kW/Ton)
FL	= Full-load chiller efficiency under peak conditions (in kW/Ton)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
$FL_{baseline}$		Lookup based on chiller type and size from Baseline Efficiencies tables below. Use Path A values for constant speed chillers and Path B values for variable speed chillers (based on proposed case).
FL_{ee}		From application.

Variable	Value	Notes
$IPLV_{baseline}$		Lookup based on chiller type and size from Baseline Efficiencies tables below. Use Path A values for constant speed chillers and Path B values for variable speed chillers (based on proposed case).
$IPLV_{ee}$		From application.
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup by city, building type and HVAC type from Appendix G.
CF	0.8	

The rated full-load kW/ton (FL) at AHRI rating conditions is used to define the efficiency under peak conditions. The IPLV as defined by AHRI is used to define the annual average efficiency. Note, chiller full-load efficiency or IPLV may also be expressed as coefficient of performance (COP). To convert chiller efficiency from COP to kW/ton, use the following equation:
kW/ton = 3.517 / COP.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[179]

Baseline Efficiencies from which Energy Savings are Calculated

Full Load and IPLV kW/Ton values listed in the tables below, per the 2020 Energy Conservation Construction Code of New York State[180] shall be used for baseline efficiency. Path A values shall be used for proposed constant speed chillers and Path B values for proposed variable speed chillers.

Path A – Constant Speed Chillers

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)
Air-Cooled Chillers	< 150 Tons	1.188	0.876
	≥ 150 Tons	1.188	0.857
Water-Cooled, Positive Displacement	< 75 Tons	0.750	0.600
	≥ 75 Tons and < 150 Tons	0.720	0.560
	≥ 150 Tons and < 300 Tons	0.660	0.540
	≥ 300 Tons and < 600 Tons	0.610	0.520
	≥ 600 Tons	0.560	0.500
Water Cooled, Centrifugal	< 150 Tons	0.610	0.550
	≥ 150 Tons and < 300 Tons	0.610	0.550
	≥ 300 Tons and < 400 Tons	0.560	0.520
	≥ 400 Tons and < 600 Tons	0.560	0.500
	≥ 600 Tons	0.560	0.500

[179] *No source specified – update pending availability and review of applicable references.*
[180] ECCCNYS 2020, Table C403.3.2(7).

Path B – Variable Speed Chillers

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)
Air-Cooled Chillers	< 150 Tons	1.237	0.759
	≥ 150 Tons	1.237	0.745
Water-Cooled, Positive Displacement	< 75 Tons	0.780	0.500
	≥ 75 Tons and < 150 Tons	0.750	0.490
	≥ 150 Tons and < 300 Tons	0.680	0.440
	≥ 300 Tons and < 600 Tons	0.625	0.410
	≥ 600 Tons	0.585	0.380
Water Cooled, Centrifugal	< 150 Tons	0.695	0.440
	≥ 150 Tons and < 300 Tons	0.635	0.400
	≥ 300 Tons and < 400 Tons	0.595	0.390
	≥ 400 Tons and < 600 Tons	0.585	0.380
	≥ 600 Tons	0.585	0.380

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a constant or variable speed electric air-cooled or water-cooled chiller with full load and IPLV efficiencies that exceed baseline. Efficiency increases with decreasing kW/Ton value, so the compliance condition efficiency values must be lower than the corresponding baseline values.

Operating Hours

Cooling equivalent full-load hours (EFLH) were calculated from DOE-2.2 simulations of prototypical buildings. The prototype building characteristics are described in Appendix A. The $EFLH_{cooling}$ for built-up HVAC systems in commercial and multifamily buildings by location, building type, and HVAC type are shown in Appendix G.

Example Calculation *(Not to be used as default)*

Two 300-ton variable speed water-cooled centrifugal chillers are installed in a new construction hotel building with VAV system located near Albany. The chillers have rated IPLV efficiency of 0.350 kW/ton and full load efficiency of 0.520 kW/ton. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times tons/unit \times (IPLV_{baseline} - IPLV_{ee}) \times EFLH_{cooling}$$

$$\Delta kW = units \times tons/unit \times (FL_{baseline} - FL_{ee}) \times CF$$

units = 2, from application
tons/unit = 300, from application

$IPLV_{baseline}$ = 0.390, from Baseline Efficiencies section tables based on chiller type and size from application
$IPLV_{ee}$ = 0.350, from application
$EFLH_{cooling}$ = 3,119, from Appendix G based on building type, HVAC type, and location from application
$FL_{baseline}$ = 0.595, from Baseline Efficiencies section tables based on chiller type and size from application
FL_{ee} = 0.520, from application
CF = 0.8, from Summary of Variables and Data Sources table

$$\Delta kWh = 2 \times 300 \times (0.390 - 0.350) \times 3{,}119 = 74{,}856.0\ kWh$$

$$\Delta kW = 2 \times 300 \times (0.595 - 0.520) \times 0.8 = 36.0\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

References

1. ECCCNYS 2020 Table C403.3.2(7): Water Chilling Packages – Efficiency Requirements.
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[ce]-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC403

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
9-17-3	9/30/2017
3-24-8	3/29/2024

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MEASURE RECOMMENDED FOR REMOVAL FROM TRM

HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

CHILLER - COOLING TOWER

Measure Description

This measure covers the installation of close approach cooling towers applied to water-cooled chillers used for space cooling. Electric consumption and summer peak coincident demand savings are achieved through the installation of an over-sized cooling tower designed to provide an approach of ≤ 6°F at standard rating conditions. This measure addresses approach temperature only, which is defined as the difference between the cold water temperature (cooling tower outlet) and ambient wet bulb temperature. Changes in condenser water set point control strategies are not included.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons \times (\Delta kWh/ton)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times tons \times (\Delta kW/ton) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
tons	= Size of cooling system (in tons) being retrofitted with a close approach tower
(ΔkWh/ton)	= Annual electric energy savings per ton of cooling
(ΔkW/ton)	= Electric demand savings per ton of cooling
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
(ΔkWh/ton)		Annual electric energy savings per ton of cooling system retrofitted with close approach tower. Look up in Appendix J based on building type, HVAC type and location.

Variable	Value	Notes
(ΔkW/ton)		Electric demand savings per ton of cooling system retrofitted with close approach tower. Look up in Appendix J based on building type, HVAC type and location.
CF	0.8	

Unit energy savings were calculated from a DOE-2.2 simulation of commercial buildings with built-up HVAC systems. The prototype building characteristics are described in Appendix A. The unit energy savings by building type across different cities in NY are shown in Appendix J.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[181]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a standard cooling tower with a 10°F approach temperature under standard rating conditions.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a close approach cooling tower with a 6°F approach temperature under standard rating conditions.

Operating Hours

The HVAC system operating hours vary by building type. Operating hour assumptions for the prototypical building models are described in Appendix A.

Example Calculation *(Not to be used as default)*

A close approach cooling tower is installed to remove heat from a 300-ton chiller plant serving a dormitory building located near Albany. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times tons \times (\Delta kWh/ton)$$

$$\Delta kW = units \times tons \times (\Delta kW/ton) \times CF$$

units = 1, from application
tons = 300, from application
(ΔkWh/ton) = 6.7, from Appendix J based on building type and location from application
(ΔkW/ton) = 0.003, from Appendix J based on building type and location from application
CF = 0.8, from Summary of Variables and Data Sources table

[181] *No source specified – update pending availability and review of applicable references.*

$$\Delta kWh = 1 \times 300 \times 6.7 = 2{,}010\ kWh$$

$$\Delta kW = 1 \times 300 \times 0.003 \times 0.9 kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

References

N/A

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
12-17-12	12/31/2017
3-24-9	3/29/2024

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LIGHTING

REFRIGERATED CASE LED

Measure Description

This measure covers the installation of horizontally or vertically mounted LED fixtures in existing commercial coolers and freezers. Refrigerated case lighting emits heat, increasing the heat rejection load of the refrigeration system. Installing more efficient LED technology in place of fluorescent fixtures reduces the energy consumption associated with the lighting components and reduces the amount of waste heat that must be rejected by the refrigeration system. This measure is only applicable in replacement scenarios.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\frac{W_{baseline} - W_{ee}}{1{,}000}\right) \times \left(1 + \frac{1}{COP_{ref}}\right) \times hrs$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{W_{baseline} - W_{ee}}{1{,}000}\right) \times \left(1 + \frac{1}{COP_{ref}}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of fixtures replaced/installed under the program
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition
W	= Rated wattage of lamp or fixture (Watts)
hrs	= Annual operating hours of refrigerated case lighting
COP_{ref}	= Coefficient of performance of refrigeration equipment
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
$W_{baseline}$		From application, based on existing conditions. If unknown, refer to the Baseline Efficiencies section for guidance on default wattage.
W_{ee}		From application.
hrs		From application. If unknown, refer to the Operating Hours section for guidance on default annual hours.
COP_{ref}		From application, using method detailed in Calculating Coefficient of Performance of Refrigeration Equipment section below. If requisite information is unavailable, use default of 2.87 for coolers and 1.62 for freezers.[182] This default shall be used only in circumstances where manufacturer/nameplate data is missing, and facility staff is not able to provide it.
CF	0.948	Taken from RLW Analytics, Inc. Coincidence Factor study, "Grocery" facility type.

Calculating Coefficient of Performance of Refrigeration Equipment (COP_{ref})
The method below shall be applied to establish the COP of refrigeration equipment for use in this measure. If condenser efficiency is unknown, use 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.[183]

$$COP_{ref} = \frac{\frac{12}{3.413}}{(\text{Comp}_{\text{eff}} + \text{Cond}_{\text{eff}})}$$

where:
Comp_{eff} = Efficiency of the cooler/freezer compressor (kW/Ton)
Cond_{eff} = Efficiency of the cooler/freezer condenser (kW/Ton)
12 = kBtu/ton
3.413 = BTUs in one watt-hour of electricity

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.948.[184]

[182] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect unweighted average efficiencies of all evaluated systems, with additional 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.
[183] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect unweighted average efficiencies of all evaluated systems, with additional 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.
[184] Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures, RLW Analytics, Inc. Spring 2007, Table i-7 (Grocery).

Baseline Efficiencies from which Energy Savings are Calculated

Baseline fixture wattage shall be the rated wattage of the existing fixture, if known. If the existing fixture type is known, but associated wattage is not, apply the wattage of the existing fixture based on the table of standard fixture wattages in Appendix C. Alternatively, refer to the table below and calculate baseline fixture wattage based on the existing fixture type and length. Wattage values in the table below are presented per fixture length linear foot – multiply the appropriate value from the table below by fixture length to derive baseline fixture wattage.[185]

Baseline Fixture[186]	W/ft
Single Row T8	9.6
Double Row T8	19.1
Single Row T12	13.3
Double Row T12	26.6

If existing fixture type is unknown, calculate baseline fixture wattage per the table above based on proposed fixture length and type. A Single Row T8 shall be assumed as the baseline case for Low Power LED Fixtures (≤ 4.5 W/ft) and a Double Row T8 shall be assumed for High Power LED Fixtures (> 4.5 W/ft).

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a refrigerated display case with LED Horizontal or Vertical Refrigerated Case Luminaires compliant with all specifications in the current, effective DLC Solid State Lighting Technical Requirements.

Operating Hours

Annual operating hours for refrigerated case lighting shall come from application based on facility operating schedule. If unavailable, refer to the "Operating Hours" section of the Commercial and Industrial Interior and Exterior Lamps and Fixtures measure for default hours of operation. By default, grocery stores shall apply a value of 4,055 hours and convenience stores shall use 6,376 hours. For lighting equipped with motion sensors, default annual run hours shall be reduced by 12%, to a value of 3,568 hours for grocery stores and 5,611 hours for convenience stores.[187]

Example Calculation *(Not to be used as default)*

Twenty 18 watt vertically mounted LED fixtures are installed in a reach-in refrigerated cooler case in a grocery store near Albany in place of twenty 40 watt fluorescent fixtures. The refrigerated case lights are illuminated approximately 5,000 hours per year. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

[185] Regional Technical Forum (RTF) UES Measure, Commercial Grocery Display Case Lighting v3.2, SavingsData&Analysis – Lighting sheet

[186] For existing T5 and T10 bulbs, lookup W/ft based on T8 bulb of equivalent row

[187] DOE Demonstration Assessment of Light-Emitting Diode (LED) Freezer Case Lighting, October 2009, Table 1. Summary of Energy Savings for Single 5-door Refrigerated Case

$$\Delta kWh = units \times \left(\frac{W_{baseline} - W_{ee}}{1{,}000}\right) \times \left(1 + \frac{1}{COP_{ref}}\right) \times hrs$$

$$\Delta kW = units \times \left(\frac{W_{baseline} - W_{ee}}{1{,}000}\right) \times \left(1 + \frac{1}{COP_{ref}}\right) \times CF$$

units = 20, from application
$W_{baseline}$ = 40, from application
W_{ee} = 18, from application
COP_{ref} = 2.87, from Summary of Variables and Data Sources table
hrs = 5,000 hours/year, from application
CF = 0.948, from Summary of Variables and Data Sources table

$$\Delta kWh = 20 \times \left(\frac{40 - 18}{1{,}000}\right) \times \left(1 + \frac{1}{2.87}\right) \times 5{,}000 = 2{,}966.55\ kWh$$

$$\Delta kW = 20 \times \left(\frac{40 - 18}{1{,}000}\right) \times \left(1 + \frac{1}{2.87}\right) \times 0.948 = 0.562\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Reduction in refrigerated case lighting power reduces waste heat that must be displaced by the system. Interactive effects are addressed in the prescribed energy savings calculation methodology.

References

1. Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007
   Available from: https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/116_RLW_CF%20Res%20C&I%20ltg.pdf
2. Regional Technical Forum (RTF) UES Measure, Commercial Grocery Display Case Lighting v3.2, July 2023
   Available from: https://rtf.nwcouncil.org/measure/display-case-lighting/

3. DOE Demonstration Assessment of Light-Emitting Diode (LED) Freezer Case Lighting, October 2009
   Available from: https://www.energy.gov/eere/amo/articles/demonstration-assessment-light-emitting-diode-led-freezer-case-lighting

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-15-4	6/1/2015
9-17-6	9/30/2017
3-24-10	3/29/2024

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MOTORS AND DRIVES

ELEVATOR DRIVE SYSTEM UPGRADE

Measure Description

This measure covers the replacement of existing traction elevator drive systems with more efficient technology, including Silicon-Controlled Rectifier (SCR) drives, Pulse Width Modulation (PWM) drives, and Variable Voltage Variable Frequency (VVVF) drives. The following upgrade configurations are applicable to this measure:

- VVVF or PWM drive systems with regenerative braking replacing SCR systems
- VVVF or PWM with or without regenerative braking or SCR drive systems replacing Motor-Generator (M-G) set systems

This measure is only applicable as a retrofit and does not cover Destination Dispatch optimization technique.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(kWh_{baseline} - kWh_{ee} + \Delta kWh_{regen}\right)$$

$$kWh_{baseline} = \frac{Cap \times (1 - OCW) \times ft/min \times 0.746}{33{,}000 \times Eff_{mech} \times Eff_{motor} \times Eff_{drive,baseline}} \times \left[LF_{avg} \times hrs + LF_{motor,idle} \times (8{,}760 - hrs) \times F_{idle}\right]$$

$$kWh_{ee} = \frac{Cap \times (1 - OCW) \times ft/min \times 0.746}{33{,}000 \times Eff_{mech} \times Eff_{motor} \times Eff_{drive,ee}} \times LF_{avg} \times hrs$$

$$\Delta kWh_{regen} = \frac{Cap \times (1 - OCW) \times ft/min \times Eff_{mech} \times Eff_{motor} \times Eff_{drive,ee} \times 0.746}{33{,}000} \times F_{regen} \times hrs$$

Summer Peak Coincident Demand Saving

$$\Delta kW = units \times \frac{Cap \times (1 - OCW) \times ft/min \times 0.746}{33{,}000 \times Eff_{mech} \times Eff_{motor}} \times LF_{avg} \times \left(\frac{1}{Eff_{drive,baseline}} - \frac{1}{Eff_{drive,ee}}\right)$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of elevators upgraded under the program
$_{baseline}$	= Characteristic of baseline condition
$_{ee}$	= Characteristic of energy efficient condition
Cap	= Elevator car capacity (lbs)
OCW	= Overbalance of counterweight as a percentage of car capacity; reflects the percentage of car capacity that the counterweight exceeds the weight of the empty car
ft/min	= Rated top velocity of car, in ft/min
Eff_{mech}	= Mechanical efficiency of elevator shaft
Eff_{motor}	= Efficiency of elevator traction/hoist motor
Eff_{drive}	= Efficiency of elevator drive system
LF_{avg}	= Average load factor of elevator traction/hoist motor
hrs	= Annual hours of active elevator operation
$LF_{motor,idle}$	= Idle mode load factor for M-G set motor
F_{idle}	= Idling factor; reflects the fraction of time the elevator is not in active operation that the M-G set is idling; set to 0 for non M-G set baseline
F_{regen}	= Regenerative braking factor; used account for fraction of active operating hours that regenerative braking produces energy savings
0.746	= Conversion factor (kW/hp) 0.746 kW equals one electric horsepower
8,760	= Hours in one year
33,000	= Conversion factor ((ft-lb/min)/hp), 33,000 foot-pounds per minute equals one electric horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
Cap		From application.
OCW		From application, calculated as the weight of the counterweight less the weight of the empty car, divided by the car capacity; i.e., $$OCW = \frac{Counterweight - Car\ Weight}{Capacity}$$ If unknown, use 0.40 as default.[188]
ft/min		From application.
Eff_{mech}	0.64	Accounts for hoistway mechanical losses (e.g., friction, gear slippage, etc.)[189]

[188] ASHRAE 90.1-2016, Table G3.9.2 Performance Rating Method Baseline Elevator Motor
[189] ASHRAE 90.1-2016, Table G3.9.2 Performance Rating Method Baseline Elevator Motor

Variable	Value	Notes
Eff_{motor}		From application. If unknown, lookup based on Motor hp from the Elevator Motor Efficiency section below.
Eff_{drive}	M-G Set = 0.77 SCR6 = 0.85 SCR12 = 0.90 PWM = 0.94 VVVF = 0.95	From application. If unknown, use defaults as specified based on drive type.[190,191]
LF_{avg}	0.35	International Organization for Standardization.[192]
hrs		From application. If unknown, refer to the Operating Hours section below to determine default annual hours based on usage profile.
F_{regen}	0.5	It is assumed that regenerative braking produces usable energy about 50% of the time that the elevator is in motion (i.e., when a lightly loaded car is raised, when a fully loaded car is lowered, and whenever the car decelerates).[193]
$LF_{motor,idle}$	0.12	Percent of full load power of M-G set in idle mode to overcome friction and provide magnetization current.[194]
F_{idle}	M-G Set Baseline = 0.6 Non M-G Set Baseline = 0.0	Conservative adjustment factor used to reduce M-G set idle mode hours to account for shutoff timer in circuit.[195]

Elevator Motor Efficiency

When actual hoist motor efficiency is unknown, the table below shall be used to determine the appropriate value for the Eff_{motor} term based on motor horsepower.[196]

Motor hp	Eff_{motor}
1.0	82.5%
1.5	84.0%
2.0	84.0%
3.0	87.5%
5.0	87.5%
7.5	89.5%

[190] MCE, Inc, Static Drives vs. Motor Generators, March 1999, pg 120 – M-G Set efficiency established as midpoint of cited typical range.
[191] International Association of Elevator Consultants, Presentation in New York City, May 2011, Slide 11
[192] ISO 25745-2:2015: Energy Performance of Lifts, Escalators and Moving Walks -- Part 2: Energy Calculation and Classification for Lifts (elevators).
[193] Baldor Motors and Drives, Elevator Application Guide, pg. 3-6.
[194] Ibid.
[195] Selected value is based on average result of variance analysis conducted using TK Elevator Energy Calculator https://design.na.tkelevator.com/tools/energy-calculator
[196] ASHRAE 90.1-2016, Table G3.9.1 Performance Rating Method Motor Efficiency Requirements

Motor hp	Eff_{motor}
10.0	89.5%
15.0	91.0%
20.0	91.0%
25.0	92.4%
30.0	92.4%
40.0	93.0%
50.0	93.0%
60.0	93.6%
75.0	94.1%
100.0	94.5%
125.0	94.5%
150.0	95.0%
200.0	95.0%

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is N/A. Applying average load factor at peak is a conservative approach for estimating summer peak demand savings. No further adjustment is required.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is an existing M-G set or SCR drive elevator system. Baseline drive efficiency shall come from application or utilize defaults based on type as indicated in the Summary of Variables and Data Sources above. All other efficiency parameters shall be established as specified in the Summary of Variables and Data Sources and are assumed consistent between baseline and compliance scenarios.

Compliance Efficiencies from which Incentives are Calculated

The compliance condition may be an elevator equipped with SCR, PWM, or VVVF drive with or without regenerative braking based on the baseline condition, as outlined in the table below:

Acceptable Elevator Replacement Configurations

Baseline Condition	Compliance Condition
M-G Set	SCR, PWM, VVVF drives (with or without regenerative braking)
SCR drive	PWM, VVVF drives (with regenerative braking)

Operating Hours

Annual hours of operation shall come from application. If annual hours are unknown, use the table below to establish default hours based on building / elevator type and/or usage profile /

frequency.[197]

Building / Elevator Type	Usage Profile / Frequency	Average Annual Hours
Multifamily Building (up to 6 dwelling units)	Very Low / Very Seldom	73.0
Small Office or Administrative Building (2 - 5 Floors; minimal usage)		
Multifamily Building 7 - 20 dwelling units)	Low / Seldom	182.5
Small Office, Hotel, or Administrative Building (2 - 5 Floors)		
Goods Lift (minimal usage)		
Multifamily Building (21 - 50 dwelling units)	Medium / Occasionally	547.5
Midsize Office, Hotel, or Administrative Building (6 - 10 Floors)		
Goods Lift (regular usage)		
Multifamily Building (51+ dwelling units)	High / Frequently	1,095.0
Large Office, Hotel or Administrative Building (10 - 25 Floors)		
Small to Midsize Hospital		
Goods Lift in Production Process w/ Single Shaft		
Large Office, Hotel or Administrative Building (26+ Floors)	Very High / Very Frequently	2,190.0
Large Hospital		
Goods Lift in Production Process w/ Multiple Shafts		

Example Calculation *(Not to be used as default)*

An elevator is upgraded to a VVVF drive system with regenerative braking from a motor-generator set. The capacity of the car is 2,500 lbs and is designed for a velocity of 180 ft/min. The efficiency of the M-G set is 77% and the hoist motor is 90% efficient. The overbalance of the counterweight as a fraction of car capacity is 0.5. The upgraded elevator is in a midsize office building and operates approximately 600 hours per year. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times \left(kWh_{baseline} - kWh_{ee} + \Delta kWh_{regen}\right)$$

$$kWh_{baseline} = \frac{Cap \times (1 - OCW) \times ft/min \times 0.746}{33{,}000 \times Eff_{mech} \times Eff_{motor} \times Eff_{drive,baseline}} \times \left[LF_{avg} \times hrs + LF_{motor,idle} \times (8{,}760 - hrs) \times F_{idle}\right]$$

$$kWh_{ee} = \frac{Cap \times (1 - OCW) \times ft/min \times 0.746}{33{,}000 \times Eff_{mech} \times Eff_{motor} \times Eff_{drive,ee}} \times LF_{avg} \times hrs$$

[197] VDI 4707, Usage categories for lifts according to VDI 4707

$$\Delta kWh_{regen} = \frac{Cap \times (1 - OCW) \times ft/min \times Eff_{mech} \times Eff_{motor} \times Eff_{drive,ee} \times 0.746}{33{,}000} \times F_{regen} \times hrs$$

$$\Delta kW = units \times \frac{Cap \times (1 - OCW) \times ft/min \times 0.746}{33{,}000 \times Eff_{mech} \times Eff_{motor}} \times LF_{avg} \times \left(\frac{1}{Eff_{drive,baseline}} - \frac{1}{Eff_{drive,ee}}\right)$$

units = 1, from application
Cap = 2,500, from application
OCW = 0.5, from application
ft/min = 180 ft/min, from application
Eff_{mech} = 0.64, from Summary of Variables and Data Sources
Eff_{motor} = 0.90, from application
$Eff_{drive,baseline}$ = 0.77, from application
LF_{avg} =0.35, from Summary of Variables and Data Sources
hrs = 600, from application
$LF_{motor,idle}$ = 0.12, from Summary of Variables and Data Sources
F_{idle} = 0.6, from Summary of Variables and Data Sources
$Eff_{drive,ee}$ = 0.95, from Summary of Variables and Data Sources
F_{regen} = 0.5, from Summary of Variables and Data Sources

$$kWh_{baseline} = \frac{2{,}500 \times (1 - 0.5) \times 180 \times 0.746}{33{,}000 \times 0.64 \times 0.90 \times 0.77} \times [0.35 \times 600 + 0.12 \times (8{,}760 - 600) \times 0.6] = 9{,}146.10\ kWh$$

$$kWh_{ee} = \frac{2{,}500 \times (1 - 0.5) \times 180 \times 0.746}{33{,}000 \times 0.64 \times 0.90 \times 0.95} \times 0.35 \times 600 = 1{,}952.00\ kWh$$

$$\Delta kWh_{regen} = \frac{2{,}500 \times (1 - 0.5) \times 180 \times 0.64 \times 0.90 \times 0.95 \times 0.746}{33{,}000} \times 0.5 \times 600 = 834.98\ kWh$$

$$\Delta kWh = 1 \times (9{,}146.10 - 1{,}952.00 + 834.98) = 8{,}029.08\ kWh$$

$$\Delta kW = 1 \times \frac{2{,}500 \times (1 - 0.5) \times 180 \times 0.746}{33{,}000 \times 0.64 \times 0.90} \times 0.35 \times \left(\frac{1}{0.77} - \frac{1}{0.95}\right) = 0.761\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

When travelling, elevators convert stored mechanical energy into electrical energy. In non-regenerative braking elevator systems, the energy is dissipated as heat. In regenerative braking elevator systems, the electrical energy is reclaimed by the building and offsets energy loads. When an elevator system is upgraded to a system with regenerative braking, energy savings are realized in the elimination of the dissipated heat and through the alleviation of building load.

References

1. ANSI/ASHRAE/IES Standard 90.1-2016 (I-P)
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Record of Revisions

Record of Revision Number	Issue Date
9-19-7	9/27/2019
3-24-11	3/29/2024

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MOTORS AND DRIVES

VARIABLE FREQUENCY DRIVE (VFD) - FAN AND PUMP

Measure Description

This measure addresses variable frequency drives applied to fans and pumps in commercial and industrial buildings. Applications covered in this section are AHU supply and return fans, CHW pumps, cooling tower fans, condenser water pumps and heating hot water pumps.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hp \times (\Delta kWh/hp)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times hp \times (\Delta kW/hp)$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
hp	= Horsepower
(ΔkWh/hp)	= Annual electric energy savings (in kWh) per controlled motor horsepower
(ΔkW/hp)	= Electric demand savings (in kW) per controlled motor horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		Horsepower rating of motor controlled by VFD, from application.
(ΔkW/hp)		Electric demand savings from VFD per horsepower of motor controlled. Lookup in Appendix K by building type and VFD application. If no deemed savings are specified, (ΔkW/hp) = 0.
(ΔkWh/hp)		Annual energy savings from VFD per horsepower of motor controlled. Lookup in Appendix K by building type, city and VFD application.

Coincidence Factor (CF)

Demand savings factors found in Appendix K represent coincident peak impacts. Therefore, no coincidence factor adjustment is required.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline system characteristics by application are as follows:

- Chilled water and hot water pumps:
  - Variable volume, constant speed secondary pumping system
    - Existing pump rides pump curve as flow varies
- Supply fans:
  - VAV system with inlet vane control
- Return fans:
  - VAV system with discharge damper control
- Cooling tower fans:
  - One speed constant volume fan
- Condenser water pumps:
  - Constant speed, constant flow condenser water pumps

Compliance Efficiency from which Incentives are Calculated

The compliance system characteristics by application are as follows:

- Chilled water and hot water pumps:
  - Variable volume, variable speed secondary pumping system
- Supply fans:
  - VAV system with VFD control
- Return fans:
  - VAV system with VFD control
- Cooling tower fans:
  - Variable speed fans controlling condenser water temperature to 85°F
- Condenser water pumps:
  - Variable speed, variable flow condenser water loop

Operating Hours

The annual energy savings from VFD per horsepower of motor controlled (ΔkWh/hp) defined in Appendix K incorporate operating hours consideration.

Example Calculation *(Not to be used as default)*

A 10 hp HVAC supply fan is equipped with a VFD in a high school building near NYC. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times hp \times (\Delta kWh/hp)$$

$$\Delta kW = units \times hp \times (\Delta kW/hp)$$

units = 1, from application
hp = 10, from application
(ΔkWh/hp) = 707, from Appendix K based on building type and VFD application

(ΔkW/hp) = 0.070, from Appendix K based on building type and VFD application

$$\Delta kWh = 1 \times 10 \times 707 = 7{,}070\ kWh$$

$$\Delta kW = 1 \times 10 \times 0.070 = 0.70\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

References

N/A

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Record of Revision Number	Issue Date
1	10/15/2010
7-13-12	7/31/2013
9-17-8	9/30/2017
3-24-12	3/29/2024

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REFRIGERATION - CONTROL

ANTI-CONDENSATION HEATER CONTROL

Measure Description

This measure covers the installation of anti-condensation heater controls on commercial walk-in and reach-in coolers and freezers. These controls save energy by reducing door heater run times based on feedback from door moisture sensors or dew point calculated via indoor air temperature and humidity sensors. Additional savings are achieved through interactive effects with the refrigeration system's compressor. Door heaters equipped with anti-condensation controls emit less heat that must be overcome by the compressor.

There are two primary categories of anti-condensation heater controls – (1) on/off controls and (2) pulse-width modulation (PWM) controls. On/off controls cycle door heaters for several minutes at a time whereas PWM controls pulse power to the door heaters at varying frequencies to provide an average level of power to the heaters to satisfy calls for heating. This measure addresses both control strategies and is applicable in retrofit and new construction scenarios.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_{DH}}{1{,}000} \times 8{,}760 \times (RF_{baseline} - RF_{ee}) \times \left(1 + \frac{1}{COP_{ref}}\right)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{8{,}760} \times \mathrm{CF}$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition
W_{DH}	= Total power of door heaters (in Watts)
RF	= Annual runtime adjustment factor; used to account for the % of annual hours door heaters run with and without heater controls
COP_{ref}	= Coefficient of performance of refrigeration equipment
CF	= Coincidence factor1,000 = Conversion factor, one kW equals 1,000 Watts

8,760 = Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
W_{DH}	$= Volts \times Amps \times \sqrt{Phase}$	From application, calculated based on door heater nameplate Volts, Amps, and Phase. If unknown, calculate default wattage as W_{DH} = SF x W/SF, where SF represents the square footage of the cooler/freezer door and W/SF is equal to 7.1 W/ft^2 for freezers and 3.0 W/ft^2 for coolers.[198]
$RF_{baseline}$	0.907	Percentage of annual hours door heaters operate without controls.[199]
RF_{ee}	On/Off Control: 0.589 Pulse-width Modulation Control: 0.428	Percentage of annual hours door heaters operate with controls, based on control type.[200]
COP_{ref}		From application, using method detailed in Calculating Coefficient of Performance of Refrigeration Equipment section below. If requisite information is unavailable, use default of 2.87 for coolers and 1.62 for freezers.[201] This default shall be used only in circumstances where manufacturer/nameplate data is missing, and facility staff is not able to provide it.
CF	0.94	

Calculating Coefficient of Performance of Refrigeration Equipment (COP_{ref})

The method below shall be applied to establish the COP of refrigeration equipment for use in this measure. If condenser efficiency is unknown, use 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.[202]

$$COP_{ref} = \frac{\frac{12}{3.413}}{(\text{Comp}_{\text{eff}} + \text{Cond}_{\text{eff}})}$$

where:

Comp_{eff} = Efficiency of the cooler/freezer compressor (kW/Ton)

Cond_{eff} = Efficiency of the cooler/freezer condenser (kW/Ton)

[198] ECCCNYS 2020, C403.10.1.9

[199] Cadmus Commercial Refrigeration Loadshape Project, October 2015, Table 5. Average Parameters – ASDH

[200] Ibid.

[201] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect unweighted average efficiencies of all evaluated systems, with additional 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.

[202] Ibid.

12 = kBtu/ton
3.413 = BTUs in one watt-hour of electricity

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.94.[203]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is glass door reach-in and walk-in refrigerated case anti-condensation heaters without temperature/humidity sensing controls.

Compliance Efficiency from which Incentives are Calculated

The compliance case is glass door reach-in and walk-in refrigerated cases with on/off or pulse-width modulating anti-condensation heater controls installed.

Operating Hours

Annual operating hours assumptions for anti-condensation door heaters with and without automated controls are embedded in runtime adjustment factors specified in the Summary of Variables and Data Sources above.

Example Calculation *(Not to be used as default)*

On/off anti-condensation heater controls are installed on door heaters on 4 reach-in refrigerated freezer case doors with a total of 600 watts. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = \frac{W_{DH}}{1{,}000} \times 8{,}760 \times (RF_{baseline} - RF_{ee}) \times \left(1 + \frac{1}{COP_{ref}}\right)$$

$$\Delta kW = \frac{\Delta kWh}{8{,}760} \times \text{CF}$$

W_{DH} = 600, from application
$RF_{baseline}$ = 0.907, from Summary of Variables and Data Sources table
RF_{ee} = 0.589, from Summary of Variables and Data Sources table based on control type
COP_{ref} = 1.62, from Summary of Variables and Data Sources table based on case type

[203] Calculated as the ratio of percent savings at system peak (weekday hour ending at 5PM) and average savings across 8,760 load shape. Load profiles taken from Cadmus Commercial Refrigeration Loadshape Project, October 2015, Table 38. ASDH Run-time Profiles by Control Type for a Weekday (WD), Saturday (Sat), and Sunday (Sun). Percent savings at system peak calculated as Uncontrolled Run Time (%) during a weekday hour ending at 5PM (Hour = 16) less All Controls Run Time (%) during a weekday hour ending at 5PM divided by Uncontrolled Run Time (%) (i.e., (90% - 48%)/90% = 47%). Average savings across 8,760 load shape derived similarly for all weekday and weekend hours, resulting in 50% average reduction. Ratio of peak to average savings is prescribed for CF (47%/50% = 0.94).

CF = 0.94, from Summary of Variables and Data Sources table

$$\Delta kWh = \frac{600}{1{,}000} \times 8{,}760 \times (0.907 - 0.589) \times \left(1 + \frac{1}{1.62}\right) = 2{,}703.14\ kWh$$

$$\Delta kW = \frac{2{,}703.14}{8{,}760} \times 0.94 = 0.290\ \text{kW}$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction of door heater operation will slightly increase space heating load. However, these impacts are negligible and not considered at this time.

Ancillary Electric Savings Impacts

Reduction in door heater operation reduces heat that must be displaced by the refrigeration system compressor and comfort cooling system. Interactive effects associated with the refrigeration system are addressed in the prescribed energy savings calculation methodology. Space cooling load impacts are negligible and not considered at this time.

References

1. Cadmus, Commercial Refrigeration Loadshape Project, October 2015.
Available from: https://neep.org/commercial-refrigeration-loadshape-report-10-2015-0

Record of Revision

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1	10/15/2010
9-17-10	9/30/2017
3-24-13	3/29/2024

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REFRIGERATION - CONTROL

EVAPORATOR FAN CONTROL

Measure Description

This measure covers the installation of on/off or multispeed controls on electronically commutated or shaded pole evaporator fan motors in walk-in and reach-in coolers and freezers. Evaporator fans in coolers and freezers that are not equipped with controls operate at constant speed continuously, even when there is no call for refrigeration and the compressor is idle. Installation of controls allows for modulation of evaporator fans, reducing fan speed or turning them off when the compressor is not running. Reduction in energy consumption results from reduced run time of the evaporator fans as well as the interactive impact of reduction in waste heat due to fan operation that must be rejected by the refrigeration system's compressor. This method addresses both sources of savings.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hp \times (\Delta kWh/hp) \times \left(1 + \frac{1}{COP_{ref}}\right)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times hp \times (\Delta kW/hp) \times \left(1 + \frac{1}{COP_{ref}}\right)$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of evaporator fans controlled
hp	= Horsepower per evaporator fan
(ΔkWh/hp)	= Annual electric savings per evaporator fan horsepower
(ΔkW/hp)	= Peak coincident demand electric savings per evaporator fan horsepower
COP_{ref}	= Coefficient of performance of refrigeration equipment

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application. If unknown, assume 1/15 hp.[204]
(ΔkWh/hp)		Lookup from Deemed Savings table below based on evaporator fan motor type and control type.
(ΔkW/hp)		Lookup from Deemed Savings table below based on evaporator fan motor type and control type.
COP_{ref}		From application, using method detailed in Calculating Coefficient of Performance of Refrigeration Equipment section below. If requisite information is unavailable, use default of 2.87 for coolers and 1.62 for freezers.[205] This default shall be used only in circumstances where manufacturer/nameplate data is missing, and facility staff is not able to provide it.

Deemed Savings (ΔkWh/hp and ΔkW/hp)[206]

Motor Type	Control Type	ΔkWh/hp	ΔkW/hp
Shaded Pole	On/Off	6,248	0.557
	Multispeed	5,217	0.532
ECM	On/Off	2,269	0.202
	Multispeed	1,895	0.193

Calculating Coefficient of Performance of Refrigeration Equipment (COP_{ref})
The method below shall be applied to establish the COP of refrigeration equipment for use in this measure. If condenser efficiency is unknown, use 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.[207]

$$COP_{ref} = \frac{\frac{12}{3.413}}{(\text{Comp}_{\text{eff}} + \text{Cond}_{\text{eff}})}$$

where:
Comp_{eff} = Efficiency of the cooler/freezer compressor (kW/Ton)
Cond_{eff} = Efficiency of the cooler/freezer condenser (kW/Ton)
12 = kBtu/ton
3.413 = BTUs in one watt-hour of electricity

[204] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, pg. 6
[205] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect unweighted average efficiencies of all evaluated systems, with additional 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.
[206] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, Table 6. Key Savings Metrics for Evaporator Fan Motor Retrofits – Equipment Only values
[207] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect unweighted average efficiencies of all evaluated systems, with additional 0.20 kW/ton for freezers and 0.16 kW/ton for coolers to reflect condenser load.

Coincidence Factor (CF)

Demand savings provided in the table above represent peak coincident summer demand savings. Coincidence factor is embedded in deemed savings values; therefore, no coincidence factor is independently prescribed.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a walk-in or reach-in cooler or freezer with shaded pole or electronically commutated evaporator fan motors that operate continuously at constant speed (i.e. with no controls installed).

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a walk-in or reach-in cooler or freezer with shaded pole or electronically commutated evaporator fan motors equipped with on/off or multispeed evaporator fan controls.

Operating Hours

Annual evaporator fan operating hours for the baseline and proposed case are embedded in the deemed savings values provided above. It is assumed that evaporator fans without controls have an effective full load annual run time of 97.8% x 8,760 = 8,567 hours. The effective full load annual run time of evaporator fans with on/off control are assumed to be 63.6% x 8,760 = 5,571 hours, while the effective full load annual run time of evaporator fans with multispeed control are assumed to be 69.2% x 8,760 = 6,062 hours.[208]

Example Calculation *(Not to be used as default)*

On/Off controls are installed on a 1/12 hp evaporator fan shaded pole motor in a walk-in cooler in a commercial facility. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times hp \times (\Delta kWh/hp) \times \left(1 + \frac{1}{COP_{ref}}\right)$$

$$\Delta kW = units \times hp \times (\Delta kW/hp) \times \left(1 + \frac{1}{COP_{ref}}\right)$$

units = 1, from application
hp = 0.0833, from application
(ΔkWh/hp) = 6,248, from Deemed Savings table based on motor and control type from application
(ΔkW/hp) = 0.557, from Deemed Savings table based on motor and control type from application

[208] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, Table 4. Average Parameters – EF Motors

COP_{ref} = 2.87, from Summary of Variables and Data Sources based case type

$$\Delta kWh = 1 \times 0.0833 \times 6{,}248 \times \left(1 + \frac{1}{2.87}\right) = 701.80\ kWh$$

$$\Delta kW = 1 \times 0.0833 \times 0.557 \times \left(1 + \frac{1}{2.87}\right) = 0.063\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction of evaporator fan operation will slightly increase space heating load. However, these impacts are negligible and not considered at this time.

Ancillary Electric Savings Impacts

Reduction in evaporator fan operation reduces heat that must be displaced by the refrigeration system compressor and comfort cooling system. Interactive effects associated with the refrigeration system are addressed in the prescribed energy savings calculation methodology. Space cooling load impacts are negligible and not considered at this time.

References

1. Cadmus, Commercial Refrigeration Loadshape Project, October 2015. Available from: https://neep.org/commercial-refrigeration-loadshape-report-10-2015-0
2. CDH Energy, "CDH All_comps_compare for kWperTon_090617REV", September 6, 2017. Available from: <Link to DMM pending>

Record of Revision

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1	10/15/2010
7-13-16	7/31/2013
1-16-8	12/31/2015
3-18-5	3/29/2018
3-24-14	3/29/2024

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APPENDIX J

COMMERCIAL HVAC UNIT SAVINGS

AIR SIDE ECONOMIZER

Building Type	City	System Type	Unit	kWh/unit
Assembly	Albany	Air-Side Economizer	ton	39
	Binghamton	Air-Side Economizer	ton	36
	Buffalo	Air-Side Economizer	ton	45
	Massena	Air-Side Economizer	ton	33
	NYC	Air-Side Economizer	ton	27
	Poughkeepsie	Air-Side Economizer	ton	33
	Syracuse	Air-Side Economizer	ton	42
Big Box Retail	Albany	Air-Side Economizer	ton	165
	Binghamton	Air-Side Economizer	ton	152
	Buffalo	Air-Side Economizer	ton	167
	Massena	Air-Side Economizer	ton	138
	NYC	Air-Side Economizer	ton	152
	Poughkeepsie	Air-Side Economizer	ton	159
	Syracuse	Air-Side Economizer	ton	165
Fast Food	Albany	Air-Side Economizer	ton	49
	Binghamton	Air-Side Economizer	ton	47
	Buffalo	Air-Side Economizer	ton	53
	Massena	Air-Side Economizer	ton	44
	NYC	Air-Side Economizer	ton	39
	Poughkeepsie	Air-Side Economizer	ton	44
	Syracuse	Air-Side Economizer	ton	49
Full Service Restaurant	Albany	Air-Side Economizer	ton	38
	Binghamton	Air-Side Economizer	ton	35
	Buffalo	Air-Side Economizer	ton	41
	Massena	Air-Side Economizer	ton	32
	NYC	Air-Side Economizer	ton	31
	Poughkeepsie	Air-Side Economizer	ton	35
	Syracuse	Air-Side Economizer	ton	38
Light Industrial	Albany	Air-Side Economizer	ton	45
	Binghamton	Air-Side Economizer	ton	39
	Buffalo	Air-Side Economizer	ton	38
	Massena	Air-Side Economizer	ton	33
	NYC	Air-Side Economizer	ton	25
	Poughkeepsie	Air-Side Economizer	ton	35
	Syracuse	Air-Side Economizer	ton	54
Primary School	Albany	Air-Side Economizer	ton	49
	Binghamton	Air-Side Economizer	ton	44
	Buffalo	Air-Side Economizer	ton	52
	Massena	Air-Side Economizer	ton	38
	NYC	Air-Side Economizer	ton	42
	Poughkeepsie	Air-Side Economizer	ton	46
	Syracuse	Air-Side Economizer	ton	41

Building Type	City	System Type	Unit	kWh/unit
Small Office	Albany	Air-Side Economizer	ton	202
	Binghamton	Air-Side Economizer	ton	195
	Buffalo	Air-Side Economizer	ton	195
	Massena	Air-Side Economizer	ton	188
	NYC	Air-Side Economizer	ton	186
	Poughkeepsie	Air-Side Economizer	ton	194
	Syracuse	Air-Side Economizer	ton	186
Small Retail	Albany	Air-Side Economizer	ton	107
	Binghamton	Air-Side Economizer	ton	101
	Buffalo	Air-Side Economizer	ton	113
	Massena	Air-Side Economizer	ton	95
	NYC	Air-Side Economizer	ton	95
	Poughkeepsie	Air-Side Economizer	ton	101
	Syracuse	Air-Side Economizer	ton	111
Religious	Albany	Air-Side Economizer	ton	9
	Binghamton	Air-Side Economizer	ton	10
	Buffalo	Air-Side Economizer	ton	7
	Massena	Air-Side Economizer	ton	6
	NYC	Air-Side Economizer	ton	6
	Poughkeepsie	Air-Side Economizer	ton	7
	Syracuse	Air-Side Economizer	ton	6
Warehouse	Albany	Air-Side Economizer	ton	3
	Binghamton	Air-Side Economizer	ton	5
	Buffalo	Air-Side Economizer	ton	2
	Massena	Air-Side Economizer	ton	4
	NYC	Air-Side Economizer	ton	2
	Poughkeepsie	Air-Side Economizer	ton	4
	Syracuse	Air-Side Economizer	ton	7
Other	Albany	Air-Side Economizer	ton	71
	Binghamton	Air-Side Economizer	ton	66
	Buffalo	Air-Side Economizer	ton	71
	Massena	Air-Side Economizer	ton	61
	NYC	Air-Side Economizer	ton	61
	Poughkeepsie	Air-Side Economizer	ton	66
	Syracuse	Air-Side Economizer	ton	70

CLOSE APPROACH COOLING TOWERS

Building Type	City	System Type	kWh/ton	kW/ton
Dormitory	Albany	Fan coil with Water Cooled Chiller	6.7	0.003
	Binghamton	Fan coil with Water Cooled Chiller	5.5	0.003
	Buffalo	Fan coil with Water Cooled Chiller	5.6	0.004
	Massena	Fan coil with Water Cooled Chiller	5.9	0.047
	NYC	Fan coil with Water Cooled Chiller	7.7	-0.006
	Poughkeepsie	Fan coil with Water Cooled Chiller	8.0	0.003
	Syracuse	Fan coil with Water Cooled Chiller	6.8	0.003

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0	10/15/2010
3-24-15	3/29/2024

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APPENDIX P

EFFECTIVE USEFUL LIFE (EUL)

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance	Air Purifier	Residential	9	ENERGY STAR® Calc[209]
	Clothes Dryer (incl. Heat Pump Clothes Dryer)	Residential	14	ENERGY STAR® M&I Scoping Report[210]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[211]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[212]
	Induction Cooktop	Residential	16	DEER 2014 EUL ID: Appl-Elec_Cooking
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[213]
Appliance Control	Advanced Power Strip (APS)	Residential	8	DEER 2014 EUL ID: Plug-OccSens
Appliance Recycling	Air Conditioner - Room (RAC) Recycling	Residential	3	DEER 2014 EUL ID: HV-RAC-RUL
	Dehumidifier Recycling	Residential	3	Assumes same RUL as RAC
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef

[209] Savings Calculator for ENERGY STAR® Qualified Appliances (last updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products
[210] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[211] ENERGY STAR® Dehumidifier Calculator. https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[212] Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Chapters 7 and 8. Department of Energy (DOE). January 30, 2015, pg. 2-12. https://www.regulations.gov/document?D=EERE-2014-BT-STD-0036-0002
[213] Retail Products Platform Product Analysis, Last Updated May 25, 2016. https://www.energystar.gov/sites/default/files/asset/document/ESPPM_Increasing%20the%20Volume%20on%20Sound%20Bars_Littlehales.pdf

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance Recycling	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr
Building Shell	Air Conditioner – Room (RAC) Cover and Gap Sealer	Residential	3	See note below[214]
	Air Leakage Sealing	Residential	15	GDS[215]
	Attic Access Insulation & Sealing	Residential	15	GDS[216]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[217]
	Insulation – Opaque Shell	Residential	25	GDS[218]
	Plastic Window Insulation	Residential	1	See Note[219]
	Storm Window	Residential	20	DOE[220]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
	Window - Film	Residential	10	DEER 2014 EUL ID: Glaz-Daylt-WinFilm
Domestic Hot Water (DHW)	Heat Pump Water Heater (HPWH) or Desuperheater for Ground Source Heat Pump (GSHP)	Residential	10	DEER 2014 EUL ID: WtrHt-HtPmp
	Indirect Water Heater	Residential	11	DEER 2014 EUL ID: WtrHt-Res-Gas
	Storage Water Heater - Gas	Residential	15	PA Group[221]
	Storage Water Heater - Electric	Residential	13	DEER 2014 EUL ID: WtrHt-Res-Elec
	Instantaneous Water Heater	Residential	20	DEER 2014 EUL ID: WtrHt-Instant-Res
DHW - Control	Low-Flow – Faucet Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Showerhead	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Thermostatic Shower Valve	Residential	10	UPC[222]

[214] Average/typical manufacturer warranty period for AC covers.
[215] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[216] Ibid.
[217] Ibid.
[218] Ibid.
[219] 1 year is assumed to be the EUL since plastic window insulation comes in the form of single-use kits that are disposed of when the heating season ends.
[220] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[221] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[222] UPC certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a. A standard that includes a lifecycle test consisting of 10,000 cycles without fail. 10,000 cycles is the equivalent of three users showering daily for more than nine years.

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner – Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
	Air Conditioner – Room (RAC)	Residential	12	GDS[223]
	Air Conditioner – PTAC	Residential	15	DEER 2014 EUL ID: HVAC-PTAC
	Boiler, Hot Water – Steel Water Tube	Residential	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	Residential	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	Residential	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	Residential	30	ASHRAE Handbook, 2015
	Boiler and Furnace - Combination ("Combi") Boiler	Residential	22	DOE[224]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER 2014[225] EUL ID: HVAC-Frnc
	Duct Sealing and Insulation	Residential	18	DEER 2014 EUL ID: HV-DuctSeal
	Electronically Commutated (EC) Motor – HVAC Blower Fan	Residential	15	DEER 2014 EUL ID: Motors-fan
	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	Residential	15	DEER 2014 EUL ID: Motors-pump

[223] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[224] Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces, February 10, 2015, Table 8.2.17. Product definition of furnaces includes electric boilers with firing rates of less than 300,000 BTU/h.
https://energy.mo.gov/sites/energy/files/technical-support-document---residential-furances_doe.pdf
[225] Based on DEER value for high efficiency boiler and instantaneous water heater.

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Energy and Heat Recovery Ventilator	Residential	14	PA Consulting Group[226]
	Furnace, Gas Fired	Residential	22	DOE[227,228]
	Gas Heat Pump	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump - Air Source (ASHP) and Air-to-Water (AWHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[229]
	Heat Pump – PTHP	Residential	15	DEER 2014 EUL ID: HVAC-PTHP
	Refrigerant Charge Correction & Tune-Up – Air Conditioner and Heat Pump	Residential	10	DEER 2014 EUL ID: HV-Ref-Chrg
	Tune-Up - Boiler	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Tune-Up - Furnace	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Unit Heater, Gas Fired	Residential	13	ASHRAE Handbook, 2015
HVAC - Control	Adaptive Photonic Control	Residential	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Advanced Boiler Control	Residential	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A

[226] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[227] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces" and "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." August 30, 2016. https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217
[228] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." December 30, 2015. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0021-0050
[229] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
HVAC - Control	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A
	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[230]
	Thermostat – All Types	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[231]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[232]
Lighting[233]	LED Lamp	Residential	Rated Life listed by ENERGY STAR® or default to 15,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known (cap at 20 years)	ENERGY STAR® Lamps[234]

[230] NYSERDA Residential Electric Submetering Manual.
[231] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. pg. 16.
[232] Based on assumed EUL of integrated fan, which is expected to be the first component to fail.
[233] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard.
https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4
[234] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, pg. 19.
https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting[235]	Light Fixture	LED (Interior)	Residential	Rated Life listed by DLC or default to 50,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known (cap at 20 years)	DLC[236]
				Rated Life listed by ENERGY STAR or default to 25,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known (cap at 20 years)	ENERGY STAR® Fixtures[237]

[235] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard.
https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4

[236] Placed on the Qualified Products List by the Design Light Consortium (DLC) 50,000 hours, according to the appropriate Application Category as specified in the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4 or higher.

[237] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.2, August 2019, pg. 18.
https://www.energystar.gov/sites/default/files/Luminaires%20V2.2%20Final%20Specification.pdf

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting[238]	Light Fixture	LED (Exterior)	Residential	Rated Life listed by ENERGY STAR or default to 35,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known (cap at 20 years)	ENERGY STAR® Fixtures[239]
	Light Fixture	LED (Inseparable)	Residential	Rated Life listed by ENERGY STAR or default to 50,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known (cap at 20 years)	ENERGY STAR® Fixtures
Lighting Control	Bi-Level Lighting		Multifamily Common Area	15	ComEd[240]
	Connected Lighting		Residential	3	GE and Philips Hue Bridge[241]

[238] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4

[239] Ibid.

[240] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant. https://www.ilsag.info/wp-content/uploads/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf

[241] Cync by General Electric Limited Warranty for Smart Bulbs and Light Strips. https://www.gelighting.com/smart-home/warranty and Philips End of Support Policy: End of Support Policy | Philips Hue (philips-hue.com)

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Motors and Drives	Pool Pump	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
	Pool Circulator Timer	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Other	Heat Pump Pool Heater	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Pool Heater	Residential	8	DOE[242]
	Solar Pool Heater	Residential	15	DOE[243]

[242] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75. https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170
[243] https://www.energy.gov/energysaver/solar-swimming-pool-heaters

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment	High Speed Fans	C&I	10	PG&E[244]
	Livestock Waterer	C&I	10	PA Consulting Group[245]
	Milk Pre-Cooler Heat Ex-changer	C&I	15	Ibid
	Refrigeration Heat Recovery	C&I	14	DEER 2014 EUL ID: HVAC-ChlrComp-Ag
	Scroll Compressor	C&I	12	DEER 2014 EUL ID: RefgWrhs-Scroll-Comp
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[246]
	Variable Speed Drive Milk Pump Plate Cooler	C&I	15	PA Consulting Group[247]
	Variable Speed Drive Vacuum Pump	C&I	15	PA Consulting Group[248]
Appliance	Air Purifier	C&I	9	ENERGY STAR® Calc[249]
	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[250]
	Clothes Washer	C&I	11	DEER 2014 EUL ID: Appl-EffCW
	Cooking Equipment[251]	C&I	12	DEER 2014 EUL IDs: Various
	Dehumidifier	C&I	12	ENERGY STAR® Calc[252]
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ENERGY STAR®Calc[253]

[244] PG&E Work Paper PGE3PAGR117, October 12, 2017.
[245] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[246] Based on EUL's for Advanced Power Strips.
[247] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[248] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[249] Savings Calculator for ENERGY STAR® Qualified Appliances (last updated October 2016). https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products
[250] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[251] Applicable to all kitchen cooking equipment not otherwise listed.
[252] ENERGY STAR® Dehumidifier Calculator. https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[253] ENERGY STAR® Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment. www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx?5da4-3d90&5da4-3d90

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Appliance	Fireplace	C&I	15	DOE[254]
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
	Induction Cooktop	C&I	16	DEER 2014 EUL ID: Appl-Elec_Cook-ing
	Refrigerator and Freezer	C&I	12	DEER 2014 EUL ID: Cook-SDRef
Appliance - Control	Advanced Power Strip (APS)	C&I	8	DEER 2014 EUL ID: Plug-OccSens
	Vending Machine and Novelty Cooler Control	C&I	5	DEER 2014 EUL ID: Plug-VendCtrler
Appliance Re-cycling	Air Conditioner – Room (RAC)	C&I	3	DEER 2014 EUL ID: HV-RAC-RUL
Building Shell	Air Curtains	C&I	15	DEER 2014 EUL ID: Motors-fan
	Air Leakage Sealing	C&I	15	GDS[255]
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[256]
	Insulation - Opaque Shell	C&I	30	ET & CEC[257]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-Win-Film
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
Compressed Air	Air Compressor	C&I	13	Other State TRMs[258]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[259]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study[260]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [261]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [262]
	Flow Controller	C&I	13	Other State TRMs [263]

[254] Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Chapters 7 and 8. Department of Energy (DOE). January 30, 2015, pg. 2-12. https://www.regulations.gov/document?D=EERE-2014-BT-STD-0036-0002

[255] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.

[256] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.

[257] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.

[258] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (December 2018). Estimates range from 10 to 15 years. Cited TRMs are reviewed annually for updates and potential to replace TRM citations with primary reference material.

[259] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission.

[260] Measure Life Study prepared for The Massachusetts Joint Utilities, Energy & Resource Solutions, 2005. http://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

[261] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (December 2018). Estimates range from 10 to 15 years. Cited TRMs are reviewed annually for updates and potential to replace TRM citations with primary reference material.

[262] Ibid.

[263] Ibid.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Compressed Air	Low Pressure Drop Filter	C&I	10	Navigant EUL Report [264]
Domestic Hot Water (DHW)	Heat Pump Water Heater (HPWH) or Desuperheater for Ground Source Heat Pump (GSHP)	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Indirect Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Instantaneous Water Heater	C&I	20	DEER 2014 EUL ID: WtrHt-Instant-Com
	Storage Tank Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
DHW - Control	DHW Temperature Turndown	C&I	RUL of DHW System **Default = 5**	N/A
	Drain Water Heat Recovery (DWHR)	C&I	30	2019 Title 24[265]
	Low-Flow – Faucet Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Pre-Rinse Spray Valve (PRSV)	C&I	5	GDS
	Low-Flow – Salon Valve	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Low-Flow – Showerhead	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Central DHW Control	C&I	15	NREL[266]
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner – PTAC	C&I	15	DEER 2014 EUL ID: HVAC-PTAC
	Air Conditioner – Unitary	C&I	15	DEER 2014 EUL ID: HVAC-airAC
	Boiler and Furnace - Combination ("Combi") Boiler	C&I	22	DOE[267]
	Boiler and Furnace -Combination ("Combi") Furnace	C&I	20	DEER 2014[268] EUL ID: HVAC-Frnc
	Boiler, Hot Water – Steel Water Tube	C&I	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	C&I	35	ASHRAE Handbook, 2015

[264] Navigant ComEd Effective Useful Life Research Report. https://www.icc.illinois.gov/docket/P2017-0312/documents/287811/files/501915.pdf
[265] 2019 Title 24, Part 6 CASE Report. "Drain Water Heat Recovery – Final Report." http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_DWHR_Final_September-2017.pdf
[266] https://www.nrel.gov/docs/fy16osti/64541.pdf
[267] Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces, February 10, 2015, Table 8.2.17. https://energy.mo.gov/sites/energy/files/technical-support-document---residential-furances_doe.pdf
[268] Based on DEER value for high efficiency boiler and instantaneous water heater.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: HVAC- ClT-wrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[269]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	Economizer –Dual Enthalpy Air Side	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	Electronically Commutated (EC) Motor - HVAC Blower Fan	C&I	15	DEER 2014 EUL ID: Motors-Fan
	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	C&I	15	DEER 2014 EUL ID: Motors-pump
	Energy and Heat Recovery Ventilator	C&I	14	PA Consulting Group[270]
	Furnace, Gas Fired	C&I	23	DOE[271,272]
	Gas Heat Pump	C&I	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Unitary & Applied	C&I	15	DEER 2014 EUL ID: HVAC-airHP
	Heat Pump – PTHP	C&I	15	DEER 2014 EUL ID: HVAC-PTHP
	Heat Pump – Ground Source (GSHP)	C&I	25	ASHRAE[273]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[274]
	Infrared Heater	C&I	17	GDS[275]

[269] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003).
[270] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[271] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces" and "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." August 30, 2016. https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217
[272] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." December 30, 2015. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0021-0050
[273] ASHRAE Owning and Operating Cost Database. https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[274] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[275] GDS Associates, Inc. "Natural Gas Efficiency Potential Study." DTE Energy. July 29, 2016. https://www.michigan.gov/documents/mpsc/DTE_2016_NG_ee_potential_study_w_appendices_vFINAL_554360_7.pdf

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Refrigerant Charge Correction & Tune Up – Air Conditioner and Heat Pump	C&I	10	DEER 2014 EUL ID: HVAC-RefChg
	Tune-Up – Boiler	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Tune-Up – Chiller System	C&I	5	WI EUL DB[276]
	Tune-Up – Furnace	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Variable Refrigerant Flow (VRF) System	C&I	15	DEER 2014 EUL ID: HVAC-VSD-pump
	Unit Heater, Gas Fired	C&I	13	ASHRAE Handbook, 2015
HVAC – Control	Adaptive Photonic Control	C&I	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Advanced Rooftop Control	C&I	16	NYSERDA[277]
	Direct Digital Control (DDC) System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Demand Control Ventilation (DCV)	C&I	15	DEER 2014 EUL ID: HVAC-VSD-DCV
	Energy Management System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Energy Management System – Guest Room	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Boiler Economizer	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	GDS[278]
	Kitchen Demand Ventilation Control	C&I	15	PG&E[279]
	Outdoor Temperature Setback Control for Hydronic Boiler	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A
	Steam Trap – Low-Pressure Space Heating	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp

[276] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

[277] NYSERDA Methodology Appendix: Assessment of Energy Efficiency and Electrification Potential in New York State Residential and Commercial Buildings study (revised April 2023), Table 3-11: HVAC Controls https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/building-stock-potential-studies/AppendixAMethodologyNYSEEandElectrificationPotentialStudyApril2023-acc.pdf

[278] Natural Gas Energy Efficiency Potential in Massachusetts, GDS Associates, 2009. https://ma-eeac.org/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

[279] PG&E Work Paper WPSDGENRCC0019, June 15, 2012.

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
HVAC – Control	Steam Trap Monitoring System – Low-Pressure Space Heating		C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Thermostat – Programmable Thermostat – Wi-Fi (Communicating)		C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve		C&I	15	DOE[280]
Lighting[281]	Light Fixture	LED Fixture (DLC)	C&I	50,000 hrs /annual lighting operating hrs or 15 yrs if annual operating hrs are not known (cap at 20 years)	DLC[282]
		LED Fixture (Interior)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hrs/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known (cap at 20 years)	ENERGY STAR®[283]
		LED Fixture (Exterior)	C&I	Rated Life listed by ENERGY STAR or default to 35,000 hrs/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known (cap at 20 years)	ENERGY STAR®[284]
		LED Fixture (Inseparable)	C&I	Rated Life listed by ENERGY STAR or default to 50,000/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known (cap at 20 years)	ENERGY STAR®[285]

[280] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. https://www.nrel.gov/docs/fy15osti/63388.pdf

[281] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4

[282] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4.

[283] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified by ENERGY STAR®.

[284] Ibid.

[285] Ibid.

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting[286]	Light Fixture	LED Fixture (Uncertified)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hrs /annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known (cap at 20 years)	Uncertified
	LED Lamp		C&I	50,000 hrs /annual lighting operating hrs or 15 yrs if annual operating hrs are not known (cap at 20 years)	DLC[287]
				Rated Life listed by ENERGY STAR or default to 15,000 hrs /annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known (cap at 20 years)	ENERGY STAR®
	LED Exit Signs & Open Signs		C&I	16	DEER 2014 EUL ID: LED-sign
	Refrigerated Case LED		C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
	Lighting Power Density (LPD)		C&I	15	GDS[288]
Lighting - Control	Bi-Level Lighting		C&I	15	ComEd[289]
	Integrated Interior Control		C&I	15	ComEd[290]
	Non-Integrated Interior Control		C&I	10	GDS[291]
	Plug-Load Occupancy Sensor		C&I	8	DEER[292]

[286] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard.
https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4
[287] DesignLights Consortium (DLC): Technical Requirement Table version 4.4 or higher.
[288] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. As directed in the Interior and Exterior Lighting measure, new construction projects may be evaluated based on LPD. This value is provided for use with new construction LPD projects only.
https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf
[289] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant.
https://www.ilsag.info/wp-content/uploads/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf
[290] Ibid.
[291] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf
[292] DEER value for lighting occupancy sensors.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Motors and Drives	Motor (incl. PEI Pumps)	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Notched & Synchronous Belt	C&I	5	DEER 2014 EUL ID: HV-CoggedBelt
Motors and Drives	Pool Pump	C&I	10	DEER 2014 EUL ID: OutD-PoolPump
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSup-Fan
	Elevator Modernization	C&I	15	DEER 2014[293]
Other	Heat Pump Pool Heater	C&I	15	DEER 2014 EUL ID: HV-Res HP
	High Efficiency Transformer	C&I	32	DOE[294]
	High Frequency Battery Charger	C&I	15	PG&E[295]
	High Viscosity Industrial Lubricant	C&I	10	ExxonMobil[296]
	Pool Heater	C&I	8	DOE[297]
	Solar Pool Cover	C&I	5	CALMAC[298]
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Steam Trap Monitoring System – Other Applications	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Ozone Laundry	C&I	10	PG&E[299]
	Process Exhaust Filtration	C&I	15	CIBSE[300]
Refrigeration	Air-Cooled Refrigeration Condenser	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Automatic Door Closer for Walk-In Cooler/Freezer	C&I	8	DEER 2014 EUL ID: GrocWlkIn-DrClsr
	Cooler and Freezer Door Gasket	C&I	4	DEER 2014 EUL ID: GrocWlkIn-WDr-Gask
	Cooler and Freezer Door Strip	C&I	4	DEER 2014 EUL ID: GrocWlkIn-Strip-Crtn
	EC Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvap-FanMtr

[293] Assumes same EUL as VFD measure.
[294] https://www.federalregister.gov/documents/2019/06/18/2019-12761/energy-conservation-program-energy-conservation-standards-for-distribution-transformers
[295] https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf, pg. 43.
[296] Information presented in the ExxonMobil study is confidential.
[297] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75. https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170
[298] http://www.calmac.org/publications/PoolCoverReport_2015_Final_Report_Appendices.pdf
[299] PG&E Work Paper PGECOAPP123, August 22, 2017.
[300] Chartered Institution of Building Services Engineers. "Probabilistic Estimation of Service Life." An industrial ventilation system consists of a fan and a set of filters; Fan and Filter EUL are 15 to 20 years depending on type. https://www.cibse.org/knowledge-research/knowledge-portal/probabilistic-estimation-of-service-life

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Refrigeration	Equipment (Condenser, Compressor, and Sub-cooling)	C&I	15	DEER 2014 EUL ID: GrocSys-MechSubcl
	Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM)	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvap-FanMtr
	Refrigerated Case Door	C&I	12	DEER 2014 EUL ID: GrocDisp-FixtDoors
	Refrigerated Case Night Cover	C&I	5	DEER 2014 EUL ID: GrocDisp-DispCvrs
	Refrigeration Condenser Coil Cleaning	C&I	1	Based on measure compliance requirements
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Condenser Pressure and Temperature Control	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Floating Head Pressure Control	C&I	10	PA Consulting Group [301]

Common References

1. DEER 2014 EUL.
   Available from: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx
2. GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007.
   Available from: https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

[301] PA Consulting Group Inc. "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report." August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Record of Revision

Record of Revision Number	Issue Date
EUL's originally listed in July 18, 2011 Order	7/18/2011
Additional EUL's posted on web site	Subsequent to 7/18/2011 Order
7-13-28	7/31/2013
6-14-1	6/19/2014
6-14-2	6/19/2014
6-15-4	6/1/2015
6-16-2	6/30/2016
1-17-8	12/31/2016
6-17-16	6/30/2017
9-17-11	9/30/2017
12-17-17	12/31/2017
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6-18-23	6/30/2018
9-18-21	9/30/2018
12-18-17	12/28/2018
3-19-16	3/29/2019
6-19-14	6/30/2019
9-19-10	9/30/2019
12-19-17	12/23/2019
3-20-17	3/30/2020
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3-21-18	3/31/2021
7-21-21	8/30/2021
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