Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-20-2	R	3/30/2020	1/1/2021	R/MF Steam Trap – Low Pressure Space Heating	Revised algorithm and corresponding assumptions/defaults per recommendation in ERS memo. Added language to where section to explain the expanded equation. Updated Failed Trap value in Summary of Variables and Data Sources Table. Added detail in the Baseline Efficiency section.	Pg. 172
3-20-4	R	3/30/2020	1/1/2021	C/I Oven, Steamer, Fryer and Griddle	Corrected/revised Default Values tables; updated references and aligned equipment operating assumptions with current references	Pg. 240
3-20-5	R	3/30/2020	1/1/2021	C/I Combination Oven	Corrected/revised Default Values tables; updated references and aligned equipment operating assumptions and category labels with current references	Pg. 218
3-20-10	R	3/30/2020	1/1/2021	C/I Steam Trap- Low Pressure Space Heating	Revised algorithm and corresponding assumptions/defaults per recommendation in ERS memo. Added language to where section to explain the expanded equation. Updated Failed Trap value in Summary of Variables and Data Sources Table. Added detail in the Baseline Efficiency section	Pg.425
3-20-11	R	3/30/2020	1/1/2021	C/I Interior and Exterior Lighting	Modified language in the Compliance Efficiency section to make it consistent with other measures. Added citation for Coincidence Factor value.	Pg. 434
3-20-12	R	3/30/2020	1/1/2021	C/I Steam Trap- Other Application	Revised algorithm and corresponding assumptions/defaults per recommendation in ERS memo. Added language to where section to explain the expanded equation. Updated Failed Trap value in Summary of Variables and Data Sources Table. Added detail in the Baseline Efficiency section	Pg.463

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-20-17	R	3/30/2020	1/1/2021	Appendix P	Updated EUL entries for all measures contained in this Record of Revision	Pg. 765
3-20-18	R	3/30/2020	1/1/2021	Glossary	Added entries to align with all measures contained in this Record of Revision	Pg. 778

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between December 24, 2019 – March 30, 2020.

HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

STEAM TRAP – LOW PRESSURE SPACE HEATING

Measure Description

This measure covers the repair or replacement of steam traps in low-pressure (≤15 psig) steam space heating applications on existing residential steam systems served by gas-fired boilers. Steam systems distribute heat from boilers to satisfy space heating requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements. This measure does not apply to municipal steam systems.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to ensure correct operation. Faulty steam traps (leaking or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam production. There are three major types of steam traps that are applicable: 1) thermostatic (including float and thermostatic), 2) mechanical and 3) thermodynamic.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times Loss_{steam} \times \frac{\Delta H_{vap}}{Eff} \times \frac{EFLH_{heating}}{100{,}000} \times F_{CR}$$

$$Loss_{steam} = 60 \times \frac{\pi}{4} \times Dia^2 \times psia^{0.97} \times F_{Discharge} \times F_{Loss}$$

$$psia = psig + p_{atm}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of steam traps repaired/replaced under the program
$Loss_{steam}$	= Hourly steam loss per failed trap (lb/hr)

ΔH_{vap} = Heat of vaporization (latent heat), in BTU/lb, at system operating pressure (psig)
Eff = Efficiency of boiler
$EFLH_{heating}$ = Equivalent full-load heating hours
F_{CR} = Condensate Return Factor, used to account for the proportion of energy lost that is returned to the system via condensate line
Dia = Internal Diameter (I.D.) of steam trap orifice
psia = Absolute steam pressure (psi)
$F_{Discharge}$ = Discharge coefficient
F_{Loss} = Steam loss adjustment factor
psig = Steam gage pressure (psi)
p_{atm} = Atmospheric pressure (psi)
60 = An empirically derived constant in the Grashof's equation (lb_m/ $in^{0.06}$-$lb^{0.97}$-hr)[1]
$\pi/4$ = Orifice area development factor
0.97 = An empirically derived constant in the Grashof equation[2]
100,000 = Conversion from Btu to therms (100,000 Btu/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$		Calculated per the equation above, dependent upon system operating pressure (psig), steam trap orifice diameter (Dia) and steam loss adjustment factor (F_{Loss}).
ΔH_{vap}		Look up from table below based on system operating pressure (psig).
Eff		Boiler efficiency, from application. Either E_t or AFUE shall be used, based on nameplate rating metric of existing equipment or actual system efficiency as provided on the application and documented by the customer.
$EFLH_{heating}$		Look up based on building type, vintage and location from Appendix G.
$F_{Discharge}$	0.7	Based on Massachusetts Steam Trap Evaluation[3]
F_{CR}	Condensate Return: 0.45 No Condensate Return: 1.00	Based on ERS memo to NYSEG/RG&E[4]
Dia		From application.
psia		Calculated per the equation above, dependent upon system operating pressure (psia).
F_{Loss}	0.37	Based on Massachusetts Steam Trap Evaluation[5]

[1] Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2" March 8, 2017. pg 6
[2] Ibid.
[3] Ibid, pg 7
[4] ERS Memo to NYSEG/RG&E, "Recommendations to Update Algorithms for C&I Steam Trap Repair Energy Savings in NY TRM Introduction", October 10, 2019
[5] Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2". March 8, 2017. Table 4-7

Variable	Value	Notes
psig		From application.
P_{atm}	14.7	Atmospheric pressure (14.7 psi).

Heat of Vaporization (Btu/lb)[6]

Pressure (psig)	Heat of Vaporization (Btu/lb)
0	970
1	968
2	966
3	964
4	962
5	961
6	959
7	957
8	956
9	954
10	953
11	951
12	950
13	948
14	947
15	946

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a leaking or blow-through steam trap on a low-pressure steam space heating system.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an intact (replaced or repaired) steam trap on a low-pressure steam space heating system. Replaced or repaired steam traps will no longer leak or blow-through after installation.

Operating Hours

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 residential buildings in NY are shown in Appendix G.

[6] Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases (1936)

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2", March 8, 2017.
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Steam-Trap-Evaluation-Phase-II.pdf
2. ERS Memo to NYSEG/RG&E, "Recommendations to Update Algorithms for C&I Steam Trap Repair Energy Savings in NY TRM Introduction", October 10, 2019
3. Joseph Henry Keenan and Frederick G. Keyes, Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases, John Wiley and Sons, New York (1936)

Record of Revision

Record of Revision Number	Issue Date
6-18-19	6/30/2018
3-20-2	3/30/2020

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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 ENERGY STAR® Commercial Food Service Equipment Calculator.[7]

- Convection Ovens[8] - 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 8,000 BTU/h or less, per assumed efficiency of qualified equipment by the Food Service Technology Center (FSTC).[9]
- Rack Ovens[10] - 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[11] - 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[12] - 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.
- Griddles[13] - This measure includes single-sided gas and electric commercial griddles. A single-sided commercial griddle is a commercial appliance designed for cooking food in

[7] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[8] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 2.2., March 2015
[9] Food Service Technology Center, Qualified Convection Ovens, February 2018
[10] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 2.2., March 2015
[11] ENREGY STAR® Program Requirements for Commercial Steam Cookers, Eligibility Criteria Version 1.2, August 2003
[12] ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 3.0. October 2016
[13] ENERGY STAR® Program Requirements for Commercial Griddles, Eligibility Criteria Version 1.2, January 2011

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 the Food Service Technology Center (FSTC).[14]

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 Gas Energy Savings (Gas Equipment Only)

$$\Delta therms = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle} + \Delta BTU_{cooking}\right)}{100{,}000}$$

where:

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

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

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

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

[14] Food Service Technology Center, Qualified Conveyor Ovens, February 2018

looked up from the Default Values table below.

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas 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
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
$BTU_{preheat}$	= 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
CF	= Coincidence factor
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta BTU_{preheat}$		Calculate based on calculations above or look up in Default Values table below.
ΔBTU_{idle}		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking}$		Calculate based on calculations above or look up in Default Values table below.
days		From application or look up based on facility type in Operating Hours section below.
hrs		From application or look up based on facility type in Operating Hours section below.
$N_{preheat}$	1	Pacific Gas and Electric. [15]
$BTU_{preheat,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU_{preheat,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$BTU/h_{idle,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.

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

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

Default Values

The table below contains values and simplified calculations for $\Delta BTU_{preheat}$, ΔBTU_{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.

Equipment	$\Delta BTU_{preheat}$	ΔBTU_{idle}	$\Delta BTU_{cooking}$
Convection Oven, Electric, Full Size	1,706	1,365 x hrs - 1,858	3,250
Convection Oven, Electric, Half Size	341	102 x hrs - 1,011	1,553
Convection Oven, Gas, Full Size	8,000	3,100 x hrs - 5,014	2,470
Convection Oven, Gas, Half Size	5,500	3,500 x hrs - 12,087	27,778
Conveyor Oven, Gas	17,000	13,000 x hrs - 55,144	124,405
Rack Oven, Gas, Double Rack	15,000	35,000 x hrs – 179,550	423,077
Rack Oven, Gas, Single Rack	6,000	18,000 x hrs - 89,017	187,500
Steamer, Electric[16]	0	14,581 x hrs – 11,229	19,385
Steamer, Gas[17]	11,000	27,378 x hrs – 23,977	42,368
Fryer, Electric, Standard	1,706	1,365 x hrs - 3,941	10,988
Fryer, Electric, Large Vat	1,194	853 x hrs - 2,005	15,268
Fryer, Gas, Standard	2,500	5,000 x hrs - 15,481	73,286
Fryer, Gas, Large Vat	5,000	4,000 x hrs - 8,636	73,286
Griddle, Electric[18]	6,834	1,638 x hrs - 7,451	5,220

[16] Assumes 6 pans
[17] Assumes 6 pans
[18] Assumes 3-foot griddle width, 2-foot griddle depth

Equipment	$\Delta BTU_{preheat}$	ΔBTU_{idle}	$\Delta BTU_{cooking}$
Griddle, Gas[19]	6,000	5,100 x hrs - 49,875	23,438

Common Variables[20]

Equipment	Value		
	$hrs_{preheat}$	lbs	Q_{food} (BTU/lb)
Convection Oven, Electric, Full Size	0.25[21]	100	250
Convection Oven, Electric, Half Size	0.25[22]	100	250
Convection Oven, Gas, Full Size	0.25[23]	100	250
Convection Oven, Gas, Half Size	0.25[24]	100	250
Conveyor Oven, Gas	0.25[25]	190	250
Rack Oven, Gas, Double Rack	0.33[26]	1,200[27]	250
Rack Oven, Gas, Single Rack	0.33[28]	600	250
Steamer, Electric	0.25[29]	100	105
Steamer, Gas	0.25[30]	100	105
Fryer, Electric, Standard	0.25[31]	150	570
Fryer, Electric, Large Vat	0.25[32]	150	570
Fryer, Gas, Standard	0.25[33]	150	570
Fryer, Gas, Large Vat	0.25[34]	150	570
Griddle, Electric	0.25[35]	100	475
Griddle, Gas	0.25[36]	100	475

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[37]

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 referenced

[19] Assumes 3-foot griddle width, 2-foot griddle depth
[20] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018), unless otherwise noted
[21] PG&E Work Paper PGECOFST101 Revision 6, Table 10, pg. 15
[22] PG&E Work Paper PGECOFST101 Revision 6, Table 9, pg. 14
[23] PG&E Work Paper PGECOFST101 Revision 6, Table 13, pg. 18
[24] PG&E Work Paper PGECOFST101 Revision 6, Table 12, pg. 18
[25] PG&E Work Paper PGECOFST117 Revision 5, Table 9, pg. 11-12, where 1 pizza equals 0.76 lbs
[26] PG&E Work Paper PGECOFST109 Revision 6, Table 7, pg. 12
[27] Ibid
[28] PG&E Work Paper PGECOFST109 Revision 6, Table 7, pg. 12
[29] PG&E Work Paper PGECOFST104 Revision 6, Table 11, pg. 13
[30] PG&E Work Paper PGECOFST104 Revision 6, Table 12, pg. 15
[31] PG&E Work Paper PGECOFST102 Revision 6, Table 10, pg. 7
[32] PG&E Work Paper PGECOFST102 Revision 6, Table 10, pg. 7
[33] PG&E Work Paper PGECOFST102 Revision 6, Table 11, pg. 10
[34] PG&E Work Paper PGECOFST102 Revision 6, Table 11, pg. 10
[35] Cal TF Work Paper SWFS004 Revision 1,pg. 7
[36] Cal TF Work Paper SWFS004 Revision 1,pg. 10
[37] Shared assumption from all PG&E Work Papers referenced in this measure

ENERGY STAR® Commercial Food Service Equipment Calculator unless otherwise noted.[38] Preheat energy and all values for half size gas convection ovens and conveyor ovens are reported from referenced FSTC sources.

Equipment	$BTU_{preheat,baseline}$ (BTU)	$BTU/h_{idle,baseline}$ (BTU/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$
Convection Oven, Electric, Full Size	5,118[39]	6,824	90	0.65
Convection Oven, Electric, Half Size	3,412[40]	3,514	45	0.68
Convection Oven, Gas, Full Size	19,000[41]	15,100	83	0.44
Convection Oven, Gas, Half Size[42]	13,000	12,000	45	0.30
Conveyor Oven, Gas[43]	35,000	70,000	114	0.20
Rack Oven, Gas, Double Rack	100,000[44]	65,000	250	0.30
Rack Oven, Gas, Single Rack	50,000[45]	43,000	130	0.30
Steamer, Electric	5,118[46]	2,047 + 3,767 x no. pans[47]	23.3 x no. pans	0.26
Steamer, Gas	20,000[48]	9,000 + 6,524 x no. pans[49]	23.3 x no. pans	0.15
Fryer, Electric, Standard	8,189[50]	4,094	65	0.75
Fryer, Electric, Large Vat	10,577[51]	4,606	100	0.70
Fryer, Gas, Standard	18,500[52]	14,000	60	0.35
Fryer, Gas, Large Vat	27,000[53]	16,000	100	0.35
Griddle, Electric	2,275 x griddle area[54]	1,365 x griddle area	5.83 x griddle area	0.65
Griddle, Gas	3,500 x griddle area[55]	3,500 x griddle area	4.17 x griddle area	0.32

Compliance Efficiency from which Incentives are Calculated

The compliance condition is ENERGY STAR® food service equipment or, in the case of conveyor ovens and half size gas convection ovens, equipment aligning with FSTC assumptions for energy

[38] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[39] PG&E Work Paper PGECOFST101 Revision 6, Table 10, pg. 15
[40] PG&E Work Paper PGECOFST101 Revision 6, Table 9, pg. 14
[41] PG&E Work Paper PGECOFST101 Revision 6, Table 13, pg. 18
[42] PG&E Work Paper PGECOFST101 Revision 6, Table 12, pg. 18
[43] PG&E Work Paper PGECOFST117 Revision 5, Table 9, pg. 11-12, where 1 pizza equals 0.76 lbs
[44] PG&E Work Paper PGECOFST109 Revision 6, Table 7, pg. 12
[45] Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
[46] PG&E Work Paper PGECOFST104 Revision 6, Table 11, pg. 13
[47] Represents energy rate when steamers are in idle mode and in constant steam mode: $(1 - Ts)*BTU/h_{idle,baseline} + Ts*(lb/hr)_{baseline}*Q_{food}/Eff_{baseline}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,baseline}$ = 3,412 BTU/h for baseline electric steamers
[48] PG&E Work Paper PGECOFST104 Revision 6, Table 11, pg. 13
[49] Represents energy rate when steams are in idle mode and in constant steam mode: $(1 - Ts)*BTU/h_{idle,baseline} + Ts*(lb/hr)_{baseline}*Q_{food}/Eff_{baseline}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,baseline}$ = 15,000 BTU/h for baseline gas steamers
[50] PG&E Work Paper PGECOFST102 Revision 6, Table 10, pg. 7
[51] Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator
[52] PG&E Work Paper PGECOFST102 Revision 6, Table 11, pg. 10
[53] Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator
[54] Cal TF Work Paper SWFS004 Revision 1,pg. 7
[55] Cal TF Work Paper SWFS004 Revision 1,pg. 10

efficient products 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. Values are as reported from the ENERGY STAR® Commercial Food Service Equipment Calculator, unless otherwise noted.[56] Preheat energy and all values for half size gas convection ovens and conveyor ovens are reported from referenced FSTC sources.

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	$(lbs/hr)_{ee}$	Eff_{ee}
Convection Oven, Electric, Full Size	3,412[57]	5,459	90	0.71
Convection Oven, Electric, Half Size	3,071[58]	3,412	50	0.71
Convection Oven, Gas, Full Size	11,000[59]	12,000	86	0.46
Convection Oven, Gas, Half Size[60]	7,500	8,500	55	0.45
Conveyor Oven, Gas[61]	18,000	57,000	167	0.42
Rack Oven, Gas, Double Rack	85,000[62]	30,000	250	0.52
Rack Oven, Gas, Single Rack	44,000[63]	25,000	130	0.48
Steamer, Electric	5,118[64]	1,678 x no. pans*[65]	16.7 x no. pans	0.50
Steamer, Gas	9,000[66]	3,463 x no. pans*[67]	20.0 x no. pans	0.38
Fryer, Electric, Standard	6,483[68]	2,730	70	0.83
Fryer, Electric, Large Vat	9,383[69]	3,753	110	0.80
Fryer, Gas, Standard	16,000[70]	9,000	65	0.50
Fryer, Gas, Large Vat	22,000[71]	12,000	110	0.50
Griddle, Electric	1,136 x griddle area[72]	1,092 x griddle area	6.67 x griddle area	0.70

[56] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[57] PG&E Work Paper PGECOFST101 Revision 6, Table 10, pg. 15
[58] PG&E Work Paper PGECOFST101 Revision 6, Table 9, pg. 14
[59] PG&E Work Paper PGECOFST101 Revision 6, Table 13, pg. 18
[60] PG&E Work Paper PGECOFST101 Revision 6, Table 12, pg. 18
[61] PG&E Work Paper PGECOFST117 Revision 5, Table 9, pg. 11-12, where 1 pizza equals 0.76 lbs
[62] PG&E Work Paper PGECOFST109 Revision 6, Table 7, pg. 12
[63] Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
[64] PG&E Work Paper PGECOFST104 Revision 6, Table 11, pg. 13
[65] Represents energy rate when steamer are in idle mode and in constant steam mode: $(1 - Ts)*BTU/h_{idle,ee} + Ts*(lb/hr/pan)*Q_{food}/Eff_{ee}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,ee}$ = 455 BTU/h x no. of pans for compliance electric steamers
[66] PG&E Work Paper PGECOFST104 Revision 6, Table 11, pg. 13
[67] Represents energy rate when steamers are in idle mode and in constant steam mode: $(1 - Ts)*BTU/h_{idle,ee} + Ts*(lb/hr/pan)*Q_{food}/Eff_{ee}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,ee}$ = 2,088 BTU/h x no. of pans for compliance gas steamers
[68] PG&E Work Paper PGECOFST102 Revision 6, Table 10, pg. 7, preheat energy assumes 15min
[69] Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator, preheat energy assumes 20min
[70] PG&E Work Paper PGECOFST102 Revision 6, Table 11, pg. 10, preheat energy assumes 15min
[71] Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator, preheat energy assumes 20min
[72] Cal TF Work Paper SWFS004 Revision 1,pg. 7

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	$(lbs/hr)_{ee}$	Eff_{ee}
Griddle, Gas	2,500 x griddle area[73]	2,650 x griddle area	7.5 x griddle area	0.38

* For steamers with greater than 6 pans, assume no. pans equals 6 for steamer idle energy rate

Operating Hours

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.[74]

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the condition 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 condition 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.

[73] Cal TF Work Paper SWFS004 Revision 1,pg. 10
[74] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E

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 2.2, October 2015
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10. Pacific Gas & Electric Company, Work Paper PGECOFST109 Commercial Rack Oven-Gas, Revision 1, October 2018
11. Pacific Gas & Electric Company, Work Paper PGECOFST104 Commercial Steam Cooker-Electric and Gas, Revision 6, June 2016
12. Pacific Gas & Electric Company, Work Paper PGECOFST102 Commercial Fryer-Electric and Gas, Revision 6, June 2016
13. California Technical Forum, Commercial Griddle-Electric and Gas, Revision 1, October 2018
14. Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
    Available from: https://caenergywise.com/calculators/natural-gas-rack-ovens/#calc

15. Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator
Available from: https://caenergywise.com/calculators/electric-fryers/#calc
16. Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator
Available from: https://caenergywise.com/calculators/natural-gas-fryers/#calc
17. 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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Record of Revision

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3-18-18	3/29/2018
3-20-4	3/30/2020

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APPLIANCE

COMBINATION OVEN

Measure Description

This measure covers the installation of ENERGY STAR® qualified gas or electric commercial combination ovens.[75] Though not eligible for ENERGY STAR® qualifications, electric combination ovens with capacities of 21 pans or greater aligning with Food Service Technology Center (FSTC) assumptions for energy efficient products per the compliance efficiencies section below are also included in the measure.[76] A combination oven combines the function of hot air convection, saturated and superheating steam heating, and combination convection/steam mode for moist heating. The oven is used for steaming, baking, roasting, re-thermalizing, and proofing of various food products.

A combination oven can also be referred to as a combi, combo, or combination oven/steamer. Combination ovens come in a range of sizes based on their capacity to accommodate 12 x 20 x 2 1/2 inch hotel pans. This measure includes half size and full size combination ovens. Measure calculations are based on oven pan capacity of full size, 2 1/2 inch hotel pans.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Equipment Only)

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

Summer Peak Coincident Demand Savings (Electric Equipment Only)

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

Annual Gas Energy Savings (Gas Equipment Only)

$$\Delta therms = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle,c} + \Delta BTU_{idle,s} + \Delta BTU_{cooking,c} + \Delta BTU_{cooking,s}\right)}{100{,}000}$$

where:

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

$$\Delta BTU_{idle,c} = \left[BTUh_{idle,c,baseline} \times \left(hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{c,baseline}}\right) - BTUh_{idle,c,ee} \times \left(hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{c,ee}}\right)\right] \times (1 - F_s)$$

[75] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2, March 2015

[76] Food Service Technology Center, Qualified Combination Ovens, February 2018

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

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

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

NOTE: $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms can be calculated per the equations above using any combination of actual qualifying equipment specifications and assumed values as defined in the 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
Δtherms	= Annual gas 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	= Baseline condition or measure
ee	= Energy efficient condition or measure
c	= Convection mode
s	= Steam mode
$BTU_{preheat}$	= 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
F_s	= Steam mode time factor
CF	= Coincidence factor
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta BTU_{preheat}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{idle,c}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{idle,s}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking,c}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking,s}$		Calculate based on calculations above or look up in Default Values table below.
days		From application or look up based on facility type in Operating Hours section below.
hrs		From application or look up based on facility type in Operating Hours section below.
$N_{preheat}$	1	Pacific Gas and Electric. [77]
$BTU_{preheat,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU_{preheat,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$BTU/h_{idle,c,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU/h_{idle,s,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU/h_{idle,c,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$BTU/h_{idle,s,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$hrs_{preheat}$	0.25	Pacific Gas and Electric. [78]
$(lbs/hr)_{c,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$(lbs/hr)_{s,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$(lbs/hr)_{c,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below
$(lbs/hr)_{s,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below
lbs	< 15 Pans: 200 15-28 Pans: 250 ≥ 29 Pans: 400	From application or use values provided[79]

[77] Cal TF Workpaper SWFS003 Revision 1, pg. 8
[78] Ibid.
[79] Ibid.

Variable	Value	Notes
$Q_{food,c}$	250	Convection mode heat to food (BTU/lb) [80]
$Q_{food,s}$	105	Steam mode heat to food (BTU/lb) [81]
$Eff_{c,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$Eff_{s,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$Eff_{c,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$Eff_{s,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
F_s	0.50	ENERGY STAR®. [82]
CF	0.9	

Default Values

The table below contains values and simplified calculations for $\Delta BTU_{preheat}$, ΔBTU_{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.

Equipment	$\Delta BTU_{preheat}$	$\Delta BTU_{idle,c}$	$\Delta BTU_{idle,s}$	$\Delta BTU_{cooking,c}$	$\Delta BTU_{cooking,s}$
Combi Electric Oven, < 15 Pans[83]	5,118	36 x hrs -1,986	5,612 x hrs - 11,848	1,827	2,338
Combi Electric Oven, 15 - 20 Pans[84]	5,971	309 x hrs -1,481	9,227 x hrs - 10,865	2,284	2,922
Combi Electric Oven, 21 - 28 Pans	5,971	2,133 x hrs - 7,997	11,089 x hrs - 25,519	3,434	6,563
Combi Electric Oven, > 28 Pans	8,974	2,133 x hrs - 5,162	15,354 x hrs - 23,579	5,495	10,500
Combi Gas Oven, < 15 Pans[85]	5,000	911 x hrs -1,641	5,073 x hrs - 5,887	3,434	1,313
Combi Gas Oven, 15 - 28 Pans[86]	6,000	1,182 x hrs - 2,942	7,026 x hrs - 11,564	4,293	1,642
Combi Gas Oven, 29 Pans[87]	8,000	507 x hrs -3,076	6,126 x hrs - 15,924	6,868	2,627
Combi Gas Oven, ≥ 30 Pans[88]	8,000	788 x hrs -1,030	14,395 x hrs - 14,021	6,868	2,627

[80] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[81] Ibid.
[82] Ibid.
[83] Assumes 10 pans
[84] Assumes 20 pans
[85] Assumes 10 pans
[86] Assumes 20 pans
[87] Assumes 29 pans
[88] Assumes 40 pans

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[89]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a combination oven as defined in the Measure Description section above with operating characteristics per the table below. Values are as reported from referenced ENERGY STAR® Commercial Food Service Calculator[90] unless otherwise noted. Preheat energy rates and all values for electric combi-ovens with capacities greater than 21 pans are reported from referenced FSTC calculators.

Equipment	$BTU_{preheat,\ baseline}$ (BTU)	$BTU/h_{idle,\ c,baseline}$ (BTU/h)	$BTU/h_{idle,\ s,baseline}$ (BTU/h)	$(lbs/hr)_{c,baseline}$	$(lbs/hr)_{s,baseline}$	$Eff_{c,baseline}$	$Eff_{s,baseline}$
Combi Electric Oven, < 15 Pans	10,236[91]	4,504	17,947	79	126	0.72	0.49
Combi Electric Oven, 15 - 20 Pans	12,795[92]	7,779	29,719	166	295	0.72	0.49
Combi Electric Oven, 21 - 28 Pans[93]	12,795	12,795	42,650	100	150	0.65	0.40
Combi Electric Oven, > 28 Pans[94]	19,210	17,913	61,416	275	350	0.65	0.40
Combi Gas Oven, < 15 Pans	18,000[95]	8,747	18,656	125	195	0.52	0.39
Combi Gas Oven, 15 - 28 Pans	22,000[96]	10,788	24,562	176	211	0.52	0.39
Combi Gas Oven, 29 Pans	32,000[97]	10,788	24,562	176	211	0.52	0.39
Combi Gas Oven, ≥30 Pans	32,000[98]	13,000	43,300	392	579	0.52	0.39

Compliance Efficiency from which Incentives are Calculated

The compliance condition is ENERGY STAR® food service equipment as defined in the Measure Description section above. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the table below. Values are as reported from the referenced ENERGY STAR® Commercial Food Service Calculator[99], unless otherwise noted. Preheat energy rates and all values for electric combi ovens with capacity greater than 21 pans are reported from referenced Cal TF workpaper.

[89] Cal TF Workpaper SWFS003 Revision 1, pg. 11
[90] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[91] Cal TF Workpaper SWFS003 Revision 1, pg 8
[92] Cal TF Workpaper SWFS003 Revision 1, pg. 9
[93] Ibid.
[94] Ibid.
[95] Cal TF Workpaper SWFS003 Revision 1, pg. 13
[96] Cal TF Workpaper SWFS003 Revision 1, pg. 14
[97] Ibid.
[98] Ibid.
[99] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)

Equipment	$BTU_{preheat, ee}$ (BTU)	$BTU/h_{idle, c,ee}$ (BTU/h)	$BTU/h_{idle, s,ee}$ (BTU/h)	(lbs/hr) $_{c,ee}$	(lbs/hr) $_{s,ee}$	Eff $_{c,ee}$	Eff $_{s,ee}$
Combi Electric Oven, < 15 Pans	5,118[100]	273 x no. pans + 1,702	454 x no. pans + 2,184	119	177	0.76	0.55
Combi Electric Oven, 15 - 20 Pans	6,824[101]	273 x no. pans + 1,702	454 x no. pans + 2,184	201	349	0.76	0.55
Combi Electric Oven, 21 - 28 Pans[102]	6,824	8,530	20,472	125	200	0.70	0.50
Combi Electric Oven, > 28 Pans[103]	10,236	13,648	30,708	325	400	0.70	0.50
Combi Gas Oven, < 15 Pans	13,000[104]	150 x no. pans + 5,425	200 x no. pans + 6,511	124	172	0.56	0.41
Combi Gas Oven, 15 - 28 Pans	16,000[105]	150 x no. pans + 5,425	200 x no. pans + 6,511	210	277	0.56	0.41
Combi Gas Oven, 29 Pans	24,000[106]	150 x no. pans + 5,425	200 x no. pans + 6,511	210	277	0.56	0.41
Combi Gas Oven, ≥ 30 Pans	24,000[107]	150 x no. pans + 5,425	200 x no. pans + 6,511	394	640	0.56	0.41

Operating Hours

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.[108]

Facility Type	Hours/Day	Days/Year
Community College	11	283
Fast Food	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
Small Office	12	250

[100] Cal TF Workpaper SWFS003 Revision 1, pg. 8
[101] Cal TF Workpaper SWFS003 Revision 1, pg. 9
[102] Ibid.
[103] Ibid.
[104] Cal TF Workpaper SWFS003 Revision 1, pg. 13
[105] Cal TF Workpaper SWFS003 Revision 1, pg. 14
[106] Ibid.
[107] Ibid.
[108] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E

Facility Type	Hours/Day	Days/Year
University	11	283

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the condition 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 condition 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 2.2, March 2015.
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   Available from: http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

STEAM TRAP – LOW PRESSURE SPACE HEATING

Measure Description

This measure covers the repair or replacement of steam traps in low-pressure (≤15 psig) steam space heating applications on existing commercial steam systems served by gas-fired boilers. Steam systems distribute heat from boilers to satisfy space heating requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements. This measure does not apply to municipal steam systems.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to ensure correct operation. Faulty steam traps (leaking or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam production. There are three major types of steam traps that are applicable: 1) thermostatic (including float and thermostatic), 2) mechanical and 3) thermodynamic.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times Loss_{steam} \times \frac{\Delta H_{vap}}{Eff} \times \frac{EFLH_{heating}}{100{,}000} \times F_{CR}$$

$$Loss_{steam} = 60 \times \frac{\pi}{4} \times Dia^2 \times psia^{0.97} \times F_{Discharge} \times F_{Loss}$$

$$psia = psig + p_{atm}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of steam traps repaired/replaced under the program
$Loss_{steam}$	= Hourly steam loss per failed trap (lb/hr)

ΔH_{vap} = Heat of vaporization (latent heat), in BTU/lb, at system operating pressure (psig)
Eff = Efficiency of boiler
$EFLH_{heating}$ = Equivalent full-load heating hours
F_{CR} = Condensate Return Factor, used to account for the proportion of energy lost that is returned to the system via condensate line
Dia = Internal Diameter (I.D.) of steam trap orifice
psia = Absolute steam pressure (psi)
$F_{Discharge}$ = Discharge coefficient
F_{Loss} = Steam loss adjustment factor
psig = Steam gage pressure (psi)
p_{atm} = Atmospheric pressure (psi)
60 = An empirically derived constant in the Grashof's equation (lb_m/ $in^{0.06}$-$lb^{0.97}$-hr)[109]
$\pi/4$ = Orifice area development factor
0.97 = An empirically derived constant in the Grashof equation[110]
100,000 = Conversion from Btu to therms (100,000 Btu/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$		Calculated per the equation above, dependent upon system operating pressure (psig), steam trap orifice diameter (Dia) and steam loss adjustment factor (F_{Loss}).
ΔH_{vap}		Look up from table below based on system operating pressure (psig).
Eff		Boiler efficiency, from application. Either E_t or AFUE shall be used, based on nameplate rating metric of existing equipment or actual system efficiency as provided on the application and documented by the customer.
$EFLH_{heating}$		Lookup based on building type and location from Appendix G.
$F_{Discharge}$	0.7	Based on Massachusetts Steam Trap Evaluation[111]
F_{CR}	Condensate Return: 0.45 No Condensate Return: 1.00	Based on ERS memo to NYSEG/RG&E[112]
Dia		From application.
psia		Calculated per the equation above, dependent upon system operating pressure (psia).
F_{Loss}	0.37	Based on Massachusetts Steam Trap Evaluation[113]

[109] Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2" March 8, 2017. pg 6
[110] Ibid.
[111] Ibid, pg 7
[112] ERS Memo to NYSEG/RG&E, "Recommendations to Update Algorithms for C&I Steam Trap Repair Energy Savings in NY TRM Introduction", October 10, 2019
[113] Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2" Table 4-7, March 8, 2017.

Variable	Value	Notes
psig		From application.
P_{atm}	14.7	Atmospheric pressure (14.7 psi).

Heat of Vaporization (Btu/lb)[114]

Pressure (psig)	Heat of Vaporization (Btu/lb)
0	970
1	968
2	966
3	964
4	962
5	961
6	959
7	957
8	956
9	954
10	953
11	951
12	950
13	948
14	947
15	946

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a leaking or blow-through steam trap on a low-pressure steam space heating system.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an intact (replaced or repaired) steam trap on a low-pressure steam space heating system. Replaced or repaired traps will no longer leak or blow-through after installation.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

[114] Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases (1936)

Effective Useful Life (EUL)

See Appendix P

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2", March 8, 2017.
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Steam-Trap-Evaluation-Phase-II.pdf
2. ERS Memo to NYSEG/RG&E, "Recommendations to Update Algorithms for C&I Steam Trap Repair Energy Savings in NY TRM Introduction", October 10, 2019
3. Joseph Henry Keenan and Frederick G. Keyes, Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases, John Wiley and Sons, New York (1936)

Record of Revision

Record of Revision Number	Issue Date
6-17-14	6/30/2017
3-20-10	3/30/2020

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LIGHTING

INTERIOR AND EXTERIOR LIGHTING

Measure Description

This section covers energy-efficient lighting equipment, such as energy-efficient lamps, energy-efficient ballasts, compact fluorescent lamps, LED lamps, and improved lighting fixtures. Improved lighting fixtures may include reflectors and other optical improvements to lighting fixtures. These technologies, taken separately or combined into an energy-efficient lighting fixture, provide the required illumination at reduced input power.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times (1 + HVAC_c)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times HVAC_g$$

New construction, space renovations or remodels may require a building permit that includes compliance with local or state energy codes. In these instances, the applicable energy code defines the baseline. The energy consumption of the efficient and baseline lighting systems are defined in terms of the lighting power density (LPD) in watts per square foot. An alternate form of the lighting equations based on LPD is as follows:

Annual Electric Energy Savings

$$\Delta kWh = area \times \left[\frac{LPD_{baseline} - LPD_{ee}}{1{,}000}\right] \times hrs_{operating} \times (1 + HVAC_c)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = area \times \left[\frac{LPD_{baseline} - LPD_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = area \times \left[\frac{LPD_{baseline} - LPD_{ee}}{1{,}000}\right] \times hrs_{operating} \times HVAC_g$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures
CF	= Coincidence factor
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
area	= Extent of space or surface
1,000	= Conversion factor, one kW equals 1,000 watts
LPD	= Lighting power density
W	= Watts
$hrs_{operating}$	= Lighting operating hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor for peak demand at NYISO coincident summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption (therms/kWh)

Summary of Variables and Data Sources

Variable	Value	Notes
$units_{baseline}$		Number of baseline measures, from application. Set equal to $Units_{ee}$ if unknown.
$units_{ee}$		Number of energy efficient measures installed under the program, from application.
$W_{baseline}$		Connected load of the baseline unit(s) displaced, from application (in Watts).
W_{ee}		Connected load of the energy-efficient unit, from application (in Watts).
$hrs_{operating}$		Lighting operating hours. From application or default, as listed below in the Operating Hours table.
$LPD_{baseline}$		Lighting power density (in W/ft^2) for baseline measure, from application, based on NYS/NYC Energy Conservation code. New construction or major renovation (as defined by applicable code/permits) only.
LPD_{ee}		Lighting power density (in W/ft^2) for energy efficient measure, from application, based on installed system design. New construction or major renovation (as defined by applicable code/permits) only.
area		Floor area illuminated by lighting system (in ft^2)

Variable	Value	Notes
$HVAC_c$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$	Exterior and Unconditioned Space: 0	HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_g$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual natural gas energy consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	Interior: See Coincidence Factor (CF) section below Exterior: 0	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. Lookup Interior CF based on facility type in Operating Hours section below.

HVAC system interaction factors are defined as the ratios of the cooling energy and demand reduction and heating energy increase per unit of lighting energy reduction. Much of the input energy for lighting systems is converted to heat that must be removed by the HVAC system. Reductions in lighting heat gains due to lighting power reduction decrease the need for space cooling and increase the need for space heating.

HVAC interaction factors vary by climate, HVAC system type and building type. Prescribed values for HVAC interaction factors for lighting energy and peak demand savings are shown in Appendix D. Lighting systems in unconditioned spaces or on the building exterior will have interaction factors of 0.0. The building types for the HVAC interactive effect factors by facility type are shown in the lighting Operating Hours table below.

Coincidence Factor (CF)

The prescribed coincidence factor for commercial exterior lighting is 0.0, since exterior lighting is generally off during daylight hours. Look up interior lighting CF from the table in the Operating Hours section below based on facility type.[115]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is assumed to be the existing and operational lighting fixture in all applications other than new construction or extensive renovations that trigger the building code. See table of standard fixture wattages in Appendix C. Note, depending on local codes, new construction, space renovations or remodels may require a building permit that includes compliance with local or state energy codes. In these instances, the applicable energy code defines the baseline.

Code LPD shall be taken from chapter C405.4: Interior Lighting Power Requirements

[115] ConEd Large C&I Program Impact and Process Evaluation Report prepared by Navigant, August 2019, slide 71

(Prescriptive) and chapter 405.5: Exterior Lighting (Mandatory) of the Energy Conservation Construction Code of New York State[116] (ECCCNYS) and the New York City Energy Conservation Code[117] (NYCECC) that are based on IECC 2015. Alternatively, ASHRAE Standard 90.1-2013 may be referenced for compliance. In both cases, either the Building Area or Space-By-Space compliance path may be used.

Compliance Efficiency from which Incentives are Calculated

The compliance condition for individual fixture/lamp replacement scenarios shall be ENERGY STAR® and/or DLC compliant products. See table of standard fixture wattages in Appendix C. Manufacturers' cut sheets may substitute for the standard fixture watts in Appendix C if available. In new construction or major renovation projects, the new lighting system power consumption should be expressed as a lighting power density (LPD) in watts per square foot. All equipment installed under the LPD method shall comply with ENERGY STAR® and/or DLC specifications, where ENERGY STAR® and/or DLC specifications for that product exist. LPD methods shall be compliant with current NY stretch code requirements.

Operating Hours

The average lighting operating hours are defined by building type, as shown in the table below. These are typical average values for the building types shown. Use building specific operating hours where available. For exterior lighting, the default annual operating hours are 4,380 hrs/yr (12 hours per day).

Facility Type	Lighting Hours (hrs/yr)	CF[118]	HVAC Int	Facility Type	Lighting Hours (hrs/yr)	CF[119]	HVAC Int
Auto Related[1]	2,810	0.89	AR	Manufacturing Facility	2,857	0.67	Ind
Automotive / Transportation Service or Repair Facility (24/7)	8,760	0.89	AR	Medical Offices	3,748	0.92	SOfc
Bakery	2,854	0.79	FS	Motion Picture Theatre	1,954	0.89	Asy
Banks	3,748	0.92	SOfc	Multi-Family (Common Areas)	7,665	0.98	MFL
Church	1,955	0.89	Rel	Museum	3,748	0.89	Asy
College–Cafeteria[2]	2,713	0.79	FS	Nursing Homes	5,840	0.92	MFL

[116] ECCCNYS 2016; C405.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
[117] NYCECC 2016; C405.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
[118] ConEd Large C&I Program Impact and Process Evaluation Report prepared by Navigant, August 2019, slide 71
[119] ConEd Large C&I Program Impact and Process Evaluation Report prepared by Navigant, August 2019, slide 71

Facility Type	Lighting Hours (hrs/yr)	CF[118]	HVAC Int	Facility Type	Lighting Hours (hrs/yr)	CF[119]	HVAC Int
College – Classes	2,586	0.54	CC	Office (General Office Types)[2]	3,013	0.92	SOfc/ LOfc
College - Dormitory	3,066	0.92	Dorm	Parking Garages	4,368	0.0	None
Commercial Condos[3]	3,100	0.92	SOfc	Parking Garages (24/7)	7,717	0.0	None
Convenience Stores	6,376	0.97	SRet	Parking Lots	4,100	0.0	None
Convention Center	1,954	0.89	Asy	Penitentiary	5,477	0.37	MFL
Court House	3,748	0.92	LOfc	Performing Arts Theatre	2,586	0.89	Asy
Dining: Bar Lounge/Leisure	4,182	0.79	FS	Police / Fire Stations (24 Hr)	7,665	0.89	Asy
Dining: Cafeteria / Fast Food	6,456	0.79	FF	Post Office	3,748	0.97	SRet
Dining: Family	4,182	0.79	FS	Pump Stations	1,949	0.67	Ind
Entertainment	1,952	0.89	Asy	Refrigerated Warehouse	2,602	0.67	RWH
Exercise Center	5,836	0.89	SRet	Religious Building	1,955	0.89	Rel
Fast Food Restaurants	6,376	0.79	FF	Restaurants	4,182	0.79	FS
Fire Station (Unmanned)	1,953	0.89	Asy	Retail	3,463	0.85	SRet/ LRet
Food Stores	4,055	0.98	Gro	School / University	2,187	0.54	Univ
Gymnasium	2,586	0.89	Asy	Schools (Jr./Sr. High)	2,187	0.54	HS
Hospitals	7,674	0.74	Hosp	Schools (Preschool/ Elementary)	2,187	0.54	Sch
Hospitals / Health Care	7,666	0.74	Hosp	Schools (Technical/ Vocational)	2,187	0.54	CC
Industrial - 1 Shift	2,857	0.67	Ind	Small Services	3,750	0.92	SOfc
Industrial - 2 Shift	4,730	0.67	Ind	Sports Arena	1,954	0.89	Asy
Industrial - 3 Shift	6,631	0.67	Ind	Town Hall	3,748	0.89	Asy
Laundromats	4,056	0.89	SRet	Transportation	6,456	0.89	Asy
Library	3,748	0.89	LOfc	Warehouse (Not Refrigerated)	2,602	0.67	WH
Light Manufacturers[2]	2,613	0.67	Ind	Waste Water Treatment Plant	6,631	0.67	Ind
Lodging (Hotels/Motels)	3,064	0.92	Hotel/ Motel	Workshop	3,750	0.67	Ind

Facility Type	Lighting Hours (hrs/yr)	CF[118]	HVAC Int	Facility Type	Lighting Hours (hrs/yr)	CF[119]	HVAC Int
Mall Concourse	4,833	0.85	LRet				

[1] New car showrooms and Big Box retail stores with evening and/or weekend hours should use the Facility Type "Retail" for lighting operating hours.
[2] Lighting operating hours data from the 2008 California DEER Update study
[3] Lighting operating hours data for offices used

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. Large Commercial & Industrial (Large C&I) Program Impact and Process Evaluation, Presented to Con Edison, Prepared by Navigant, August 2019
   Available from:
   http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B614F67CD-8511-4E76-A963-38B3079505B5%7D
2. ECCCNYS 2016, per IECC 2015; Chapter C405.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
3. NYCECC 2016: Chapter C405.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
   Available from: https://www1.nyc.gov/site/buildings/codes/2016-energy-conservation-code.page
4. Lighting operating hour data taken from the CL&P and UI Program Savings Documentation for 2008 Program Year, with exceptions as noted.
   Available from:
   https://library.cee1.org/system/files/library/8821/CEE_Eval_2008ProgramSavingsDocumentPSD_1Jan2008.pdf
5. Additional lighting operating hour data taken from 2008 DEER Update – Summary of Measure Energy Analysis Revisions, August, 2008
   Available from: www.deeresources.com

6. Small Business Direct Install Program Evaluation Review, Prepared for the New York State Department of Public Service-E^2 Working Group, by the Small Commercial EM&V Review subcommittee, April 3, 2015
Available from:
https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/96006876d01739b785257c85005a58e3/$FILE/ATTGYZRG.pdf/SBDI%20EMV%20studies%20-%20Final%20Report%20-%202015-01-30.pdf

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6-19-10	6/28/2019
3-20-11	3/30/2020

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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[120]
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[121]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[122]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[123]
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[124]
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
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef
	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr

[120] Savings Calculator for ENERGY STAR® Qualified Appliances (last updated October 2016) Available from: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products

[121] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.

[122] ENERGY STAR® Dehumidifier Calculator https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

[123] 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

[124] Retail Products Platform Product Analysis, Last Updated May 25, 2016. Available from: https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Building Shell	Air Conditioner – Room (RAC) Cover and Gap Sealer	Residential	5	See note below[125]
	Air Leakage Sealing	Residential	15	GDS[126]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[127]
	Insulation – Opaque Shell	Residential	25	GDS[128]
	Storm Window	Residential	20	DOE[129]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
Domestic Hot Water	Heat Pump Water Heater (HPWH)	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 Consulting Group[130]
	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
	Solar Pool Heater	Residential	15	DOE[131]
Domestic Hot Water - Control	Drain Water Heat Recovery	Residential	30	2019 Title 24[132]
	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 Restriction Valve	Residential	10	UPC[133]

[125] At least one manufacturer's warranty period. www.gss-ee.com/products.html
[126] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[127] Ibid.
[128] Ibid.
[129] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[130] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. Available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[131] https://www.energy.gov/energysaver/solar-swimming-pool-heaters
[132] 2019 Title 24, Part 6 CASE Report. "Drain Water Heat Recovery – Final Report." Available from: http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_DWHR_Final_September-2017.pdf
[133] 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[134]
	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[135]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER[136]
	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
	Furnace, Gas Fired	Residential	22	DOE[137,138]
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP

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

[135] 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
Available from: https://energy.mo.gov/sites/energy/files/technical-support-document---residential-furances_doe.pdf

[136] Based on DEER value for high efficiency boiler and instantaneous water heater

[137] 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. Available from: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217

[138] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." December 30, 2015. Available from: https://www.regulations.gov/document?D=EERE-2013-BT-STD-0021-0050

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[139]
	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-RefChrg
	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	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.)	N/A
	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[140]
	Thermostat – Programmable Setback Thermostat – Wi-Fi (Communicating) Thermostat – Learning	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[141]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[142]

[139] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[140] NYSERDA Residential Electric Submetering Manual
[141] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. Cost-Benefit Financial Assumptions, pg. 16
[142] Based on assumed EUL of integrated fan, which is expected to be the first component to fail

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Lighting	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	ENERGY STAR® Lamps[143]
			50,000 hours	DLC[144]

[143] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, p. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

[144] 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

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED (Interior)	Residential	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	ENERGY STAR® Fixtures[145]
		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	ENERGY STAR® Fixtures
		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	ENERGY STAR® Fixtures
Lighting Control	Bi-Level Lighting		Multifamily Common Area	15	ComEd[146]

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

[146] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant Available from:
http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Motors and Drives	Pool Pump	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Other	Pool Heater	Residential	8	DOE[147]

[147] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75 Available from: https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment	High Speed Fans	C&I	10	PG&E[148]
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[149]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[150]
	Cooking Equipment[151]	C&I	12	DEER 2014 EUL IDs: Various
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ENERGY STAR®Calc[152]
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
	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 Recycling	Air Conditioner – Room (RAC)	C&I	9	DEER 2014 EUL ID: HV-RAC-ES
Building Shell	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[153]
	Insulation - Opaque Shell	C&I	30	ET & CEC[154]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-WinFilm
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
	Air Curtains	C&I	15	DEER 2014 EUL ID: Motors-fan

[148] PG&E Work Paper PGE3PAGR117, October 12, 2017
[149] Based on EUL's for Advanced Power Strips
[150] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[151] Applicable to all kitchen cooking equipment not otherwise listed
[152] 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
[153] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[154] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Compressed Air	Air Compressor	C&I	13	Other State TRMs[155]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[156]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study C&I Retrofit EUL[157]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [158]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [159]
Domestic Hot Water (DHW)	Domestic Hot Water Tank Blanket	C&I	7	DEER
	Heat Pump Water Heater (HPWH)	C&I	10	DEER
	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	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[160]
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[161]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER[162]

[155] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (March 2015). Estimates range from 10 to 15 years.
[156] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[157] 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
[158] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (March 2015). Estimates range from 10 to 15 years.
[159] Ibid.
[160] https://www.nrel.gov/docs/fy16osti/64541.pdf
[161] Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces, February 10, 2015, Table 8.2.17
Available from: https://energy.mo.gov/sites/energy/files/technical-support-document---residential-furances_doe.pdf
[162] 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, 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
	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-ClTwrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[163]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	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
	Economizer –Dual Enthalpy Air Side	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	Furnace, Gas Fired	C&I	23	DOE[164],[165]
	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 – Water Source (WSHP)	C&I	25	ASHRAE[166]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[167]
	Infrared Heater	C&I	17	GDS[168]

[163] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)
[164] 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. Available from: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217
[165] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." December 30, 2015. Available from: https://www.regulations.gov/document?D=EERE-2013-BT-STD-0021-0050
[166] ASHRAE Owning and Operating Cost Database
Available from: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[167] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. Available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[168] GDS Associates, Inc. "Natural Gas Efficiency Potential Study." DTE Energy. July 29, 2016. Available from: 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[169]
	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	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
	Kitchen Demand Ventilation Control		C&I	15	PG&E[170]
	Outdoor Temperature Setback Control for Hydronic Boiler		C&I	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.)	N/A
	Steam Trap – Low-Pressure Space Heating		C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Thermostat – Programmable Thermostat – Wi-Fi (Communicating)		C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve		C&I	15	DOE[171]
Lighting	Light Fixture	LED Fixture (DLC)	C&I	50,000 hours /annual lighting operating hours or 15 yrs if annual operating hours are not known	DLC[172]

[169] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[170] PG&E Work Paper WPSDGENRCC0019, June 15, 2012
[171] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf
[172] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED Fixture (Interior)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hours/annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®[173]
		LED Fixture (Exterior)	C&I	Rated Life listed by ENERGY STAR or default to 35,000 hours/annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®[174]
		LED Fixture (Inseparable)	C&I	Rated Life listed by ENERGY STAR or default to 50,000/annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®[175]
		LED Fixture (Uncertified)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hours /annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	Uncertified

[173] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.1. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns
[174] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.1. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns
[175] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.1. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	LED Lamp	C&I	50,000 hours	DLC[176]
			Rated Life listed by ENERGY STAR or default to 15,000 hours /annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
	Lighting Power Density (LPD)	C&I	15	GDS[177]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[178]
	Integrated Interior Lighting Control	C&I	15	ComEd[179]
	Non-Integrated Interior Lighting Control	C&I	10	GDS[180]
	Plug-Load Occupancy Sensor	C&I	8	DEER[181]
Motors and Drives	Motor	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
	Elevator Modernization	C&I	15	DEER 2014[182]
Other	Pool Heater	C&I	8	DOE[183]

[176] 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

[177] 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.
Available from: https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf

[178] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant
Available from:
http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf

[179] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant
Available from:
http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf

[180] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
Available from: https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf

[181] DEER value for lighting occupancy sensors

[182] Assumes same EUL as VFD measure.

[183] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75 Available from:
https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Ozone Laundry	C&I	10	PG&E[184]
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
	Cooler and Freezer Door Gasket	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	Cooler and Freezer Door Strip	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	Electronically Commutated (EC) Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	Equipment (Condenser, Compressor, and Sub-cooling)	C&I	15	DEER
	Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM)	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	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 - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Condenser Pressure and Temperature Control	C&I	15	DEER
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Floating Head Pressure Control	C&I	10	PA Consulting Group [185]

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

[184] PG&E Work Paper PGECOAPP123, August 22, 2017

[185] 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 Number	Issue Date
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
3-18-21	3/31/2018
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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GLOSSARY

ABBREVIATIONS, ACRONYMS, AND EQUATION VARIABLES	
$\overline{COP}$	Average coefficient of performance
$\overline{\Delta T}$	Average temperature difference
$\overline{EER}$	Seasonal average energy efficiency ratio over the cooling season BTU/watt-hour, (used for a particular climate/building)
ΔkW	Peak coincident demand electric savings
ΔkWh	Annual electric energy savings
ΔQ	Heat difference/loss
ΔT	Temperature difference
Δtherms	Annual gas energy savings
Δ	Change, difference, or savings
A	Amperage
AC	Air conditioning
ACCA	Air Conditioning Contractors of America
ACEEE	American Council for an Energy-Efficient Economy
ACL	Actual cooling load (BTU/h) based on Manual J calculation
ACH	Air change per hour
AFUE	Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
AHAM	Association of Home Appliance Manufacturers
AHL	Actual heating load (BTU/h) based on Manual J calculation
AHRI	Air Conditioning Heating and Refrigeration Institute
AHU	Air handling unit
AIA	American Institute of Architects
AIR_{loss}	Air loss percentage in a compressed air line
ANSI	American National Standards Institute
APU	Auxiliary power unit
area	Extent of space or surface
ARI	Air-Conditioning & Refrigeration Institute
ARRA	American Recovery and Reinvestment Act of 2009
ASHP	Air source heat pump
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
baseline	Baseline condition or measure
BLDC	Brushless DC electric motor
BG&E	Baltimore Gas and Electric
BTU	British Thermal Unit
BTU/h	British Thermal Units per hour
CAC	Central air conditioner
CADR	Clean Air Delivery Rate (CFM)
Capacity	Cooling output rating, in BTU/h

CAV	Constant air volume
CBECS	Commercial Buildings Energy Consumption Survey
CDD	Cooling degree days - The number of degrees that a day's average temperature is above some baseline temperature, which represents the temperature above which buildings need to be cooled. The baseline temperature is typically 65°F, but may vary based on application.
CEC	State of California Energy Commission
CEE	Consortium for Energy Efficiency
CEF	Combined energy factor (lb/kWh)
CEER	Combined Energy Efficiency Ratio
CF	Coincidence factor
CFL	Compact fluorescent lamp
CFM	Cubic foot per minute
CHW	Chilled water
CHWP	Chilled water pump
CLH	Cooling load hours
CM	Case motor
CMU	Concrete masonry
$Comp_{eff}$	Efficiency of the cooler/freezer compressor (kW/Ton)
COP	Coefficient of performance, ratio of output energy/input energy
CV	Constant volume
CW	Condenser water
CWP	Condenser water pump
Cycle	Compressor duty cycle
$Cycles_{annual}$	Number of dryer cycles per year
D	Demand
DC	Direct current
DCV	Demand controlled ventilation
DEER	Database for Energy Efficiency Resources, California
DF	Demand diversity factor
DFP	Default functional period
DHW	Domestic hot water
Dia	Diameter
DLC	DesignLights Consortium®
DOAS	Dedicated outdoor air system
DOE 2.2	US DOE building energy simulation, and cost calculation tool
DPS	Department of Public Service, New York State
DSF	Demand savings factor
DWHR	Drain Water Heat Recovery
DX	Direct expansion
ECCC NYC	Energy Conservation Construction Code of New York City
ECCC NYS	Energy Conservation Construction Code of New York State
EC	Electronically commutated
Econ	Economizer

Ecotope	Ecotope Consulting, Redlands, CA
ee	Energy efficient condition or measure
EEPS	Energy Efficiency Portfolio Standard
EER	Energy efficiency ratio under peak conditions
EF	Energy factor
Eff	Efficiency
E_c	Combustion efficiency
Efficiency Vermont	State of Vermont Energy and Efficiency Initiatives
E_t	Thermal efficiency
EFLH	Equivalent full-load hours
EIA	Energy Information Administration, US
EISA	Energy Independence and Security Act (EISA) of 2007
ElecSF	Electric Savings Factor
ENERGY STAR®	U.S. Environmental Protection Agency voluntary program
Energy Trust	Energy Trust of Oregon, Inc.
EPA	Environmental Protection Agency (EPA), US
EPACT	Energy Policy and Conservation Act of 2005
EPDM	Ethylene propylene diene monomer roofing membrane
ERV	Energy recovery ventilation
ESF	Energy savings factor
EUL	Effective useful life
EFan	Evaporator fan
Exh	Exhaust
F	Factor
F_{derate}	Aggregate derating factor
F_{elec}	Percentage of energy consumed that is derived from electricity
F_{gas}	Percentage of energy consumed that is derived from gas
F_h	Zone correction for blower door infiltration rate to natural air changes
F_n	Height correction for blower door infiltration rate to natural air changes
F_{peak}	Peak operation factor
FEMP	Federal Energy Management Program
FL	Full-load chiller efficiency under peak conditions
FLH	Full-load hours
Flow	Nozzle flow
FPFC	Four pipe fan coil
ft	Foot
ft^2	Square feet
ft^3	Cubic feet
GasSF	Gas Savings Factor
GDS	GDS Associates, Marietta, GA
Glazing area	Aperture area of glazing
GPD	Gallons Per Day

GPM	Gallons Per Minute
GSHP	Ground source heat pump
ΔH_{vap}	Heat of vaporization (latent heat), in BTU/lb
$H_2O_{savings}$	Water savings
HDD	Heating degree days - The number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application.
HID	High intensity discharge lamp
hp	Horsepower
hp_{max}	Maximum motor horsepower
hp_{peak}	Horsepower at which motor achieves peak efficiency
HP	High performance
hrs	Hours
$hrs_{operating}$	Operating hours
HSPF	Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt-hour)
ht	Height
HVAC	Heating, ventilation, and air conditioning
$HVAC_c$	HVAC interaction factor for annual electric energy consumption
$HVAC_d$	HVAC interaction factor at utility summer peak hour
$HVAC_g$	HVAC interaction factor for annual natural gas consumption
HW	Hot water
IECC	International Energy Conservation Code
IEER	Integrated energy efficiency ratio
IESNA	Illuminating engineering Society of North America
IHR	Ice Harvest Rate (lbs/day)
IPLV	Integrated Part-Load Value, a performance characteristic, typically of a chiller capable of capacity modulation.
k	Thermal conductivity
$kBTU/h_{in}$	Input rating (kBTU/h)
$kBTU/h_{out}$	Output rating (kBTU/h)
kgal	Thousand gallons
kSF	Thousand square feet
kW	kilowatts
l	Length
LBNL	Lawrence Berkeley National Laboratory
leakage	Estimate of percent of units not installed in service territory
LED	Light emitting diode
LEED	Leadership in Energy and Environmental Design
LF	Load Factor
Load	Average total weight (lbs) of clothes per drying cycle
LPD	Lighting power density

LRAC	Long-run avoided cost
LSAF	Load shape adjustment factor
MEC	Metropolitan Energy Center
min	Minutes
NACH	Natural Air Changes
NAECA	National Appliance Energy Conservation Act of 1987
NBI	New Buildings Institute
NCEI	National Centers for Environmental Information
NEA	National Energy Alliances
NEAT	National Energy Audit Tool
NEMA	National Electrical Manufacturers Association
NREL	National Renewable Energy Laboratory
NRM	National Resource Management
NSTAR	Operating company of Northeast utilities
NWPPC	Northwest Power Planning Council
NWRTF	Northwest Regional Technical Forum
NY DPS	New York State Department of Public Service
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
^{o}F	Degrees Fahrenheit
OSA	Outdoor supply air
Pa	Pascals, the standard unit of pressure or stress in the International system of units (SI)
PA Consulting	PA Consulting Group
PF	Power factor
Phase	Number of phases in a motor (1 or 3) Single Phase is a type of motor with low horsepower that operates on 120 or 240 volts, often used in residential appliances. Three phase is a motor with a continuous series of three overlapping AC cycles offset by 120 degrees. Three-phase is typically used in commercial applications.
PLR	Power loss reduction
PNNL	Pacific Northwest National Laboratory
PSC	Public Service Commission, New York State
PSF	Proper sizing factor
p_{atm}	Atmospheric pressure (lbs per square inch)
psig	Gauge pressure (lbs per square inch)
psia	Absolute steam pressure (psi)
PSZ	Packaged single zone
PTAC	Package terminal air conditioner
PTHP	Packaged terminal heat pump
Q	Heat
$Q_{reduced}$	Reduced heat
Q_{reject}	Total heat rejection
r	Radius

RA	Return air
RAC	Room air conditioner
RE	Recovery efficiency
RECS	Residential Energy Consumption Survey
RESNET	Residential Energy Services Network
RH	Reduced heat
RLF	Rated load factor
RPM	Revolutions per minute
R-value	A measure of thermal resistance particular to each material
S	Savings
SAPA	State Administrative Procedure Act
SBC	System Benefit Charge
SCFM	Standard cubic feet per minute @ 68 ^{o}F and 14.7 psi standard condition
SEER	Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
SF	Square foot
SHGC	Solar heat gain coefficient
SL	Standby heat loss
Staff	NYS Department of Public Service Staff
standby	Standby Power (watts)
T	Temperature
TAF	Temperature adjustment factor
TDA	Total Display Area (ft^2)
TDEC	Total Daily Energy Consumption
TEFC	Totally enclosed fan cooled
th	Thickness
therm	Unit of heat
THR	Total heat rejection
$Throttle_{fac}$	Throttle factor
TMY	Typical meteorological year
tons	Tons of air conditioning
tons/unit	Tons of air conditioning per unit, based on nameplate data
TRC	Total Resources Cost
TRM	Technical Resource Manual
UA	Overall heat loss coefficient (BTU/h-°F)
UA/L	Overall heat loss coefficient per unit length (BTU/h-°F-ft)
UEF	Uniform Energy Factor
unit	Measure
units	Number of measures installed under the program
UPC	Uniform Plumbing Code under the International Association of Plumbing and Mechanical Officials
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
U-value	Measure of heat loss in a building element/overall heat transfer co-efficient

V	Volt
v	Volume
VAV	Variable air volume
VSD	Variable speed drive
W	watts
W_{ctrl}	Total wattage of controlled lighting (watts)
Wisconsin PSC	State of Wisconsin Public Service Commission

EQUATION CONVERSION FACTORS	
0.000584	Conversion factor used in DOE test procedure
0.00132	Electric efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.
0.0019	Natural gas efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.
0.284	Conversion factor, one kW equals 0.284 ton
0.293	Conversion factor, one BTU/h equals 0.293071 watt
0.473	Conversion factor (liters/pint)
0.67	Natural gas water heater Energy Factor
0.746	Conversion factor (kW/hp), 746 watts equals one electric horsepower
0.97	Electric resistance water heater Energy Factor
1.08	Specific heat of air × density of inlet air @ 70°F × 60 min/hr
1.6	Typical refrigeration system kW/ton
3.412	Conversion factor, one watt-hour equals 3.412 BTU
3.517	Conversion factor, one ton equals 3.517 kilowatts
8.33	Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit
12	(kBTU/h)/ton of air conditioning capacity
24	Hours in one day
67.5	Ambient air temperature °F
91	Days in winter months
100	Conversion factor, one therm equals 100 kBTU
274	Days in non-winter months.
365	Days in one year
3,412	Conversion factor, one kWh equals 3,412 BTU
8,760	Hours in one year
1,000	Conversion factor, one kW equals 1,000 watts
12,000	Conversion factor, one ton equals 12,000 BTU/h
100,000	Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Record of Revision

Record of Revision Number	Issue Date
0	12/10/2014
6-15-4	6/1/2014
1-17-9	12/31/2016
6-17-17	6/30/2017
9-17-12	9/30/2017
12-17-18	12/31/2017
3-18-22	3/29/2018
6-19-15	6/30/2019
3-20-18	3/30/2020

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