Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-11	R	6/26/2018	6/26/2018	C/I Demand Control Ventilation (DCV)	Added detail to the Measure Description regarding code compliance, restrictions to existing conditions and development of heating side savings; Added NYC ESF values; Updated Baseline Efficiency requirement	Pg. 254
6-18-15	A	6/26/2018	6/26/2018	R/MF Boiler Tune-Up	New Measure Added	
6-18-16	A	6/26/2018	6/26/2018	R/MF Steam Trap Repair or Replacement – Low Pressure Space Heating	New Measure Added	
6-18-17	A	6/26/2018	6/26/2018	R/MF Pool Pumps	New Measure Added	
6-18-18	A	6/26/2018	6/26/2018	C/I Dishwasher	New Measure Added	
6-18-19	A	6/26/2018	6/26/2018	C/I Ice Maker	New Measure Added	
6-18-20	A	6/26/2018	6/26/2018	C/I Instantaneous Water Heater	New Measure Added	
6-18-21	R	6/26/2018	1/1/2019	Appendix P[1]	Updated EUL entries for all measures contained in this Record of Revision.	Pg. 577
6-18-22	R	6/26/2018	1/1/2019	Glossary[2]	Added entries to align with all measures contained in this Record of Revision.	Pg. 588

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between April 1, 2018 – June 26, 2018.

[1] Please note the EUL's in Appendix P included in this filing are effective 6/26/2018 for the following measures: 6-18-11 C/I Demand Control Ventilation (DCV), 6-18-15 R/MF Boiler Tune-Up, 6-18-16 R/MF Steam Trap Repair or Replacement – Low Pressure Space Heating, 6-18-17 R/MF Pool Pumps, 6-18-18 C/I Dishwasher, 6-18-19 C/I Ice Maker and 6-18-20 C/I Instantaneous Water Heater.

[2] Please note the terms in the Glossary included in this filing are effective 6/26/2018 for the following measures: 6-18-11 C/I Demand Control Ventilation (DCV), 6-18-15 R/MF Boiler Tune-Up, 6-18-16 R/MF Steam Trap Repair or Replacement – Low Pressure Space Heating, 6-18-17 R/MF Pool Pumps, 6-18-18 C/I Dishwasher, 6-18-19 C/I Ice Maker and 6-18-20 C/I Instantaneous Water Heater.

DEMAND CONTROL VENTILATION (DCV)

Measure Description

Demand control ventilation systems have the capability to automatically reduce the outdoor air intake below design rates when occupancy of spaces served by the system is less than design occupancy. Typically, this is controlled by a carbon dioxide sensor, occupancy sensor or turnstile counter. Demand control ventilation systems save energy by reducing the amount of outside air which requires heating or cooling.

This measure assumes a demand control ventilation system with CO_2 sensors will be added to an existing HVAC system with natural gas heating that previously had no DCV system or ventilation heat recovery equipment installed. The as-built condition must comply with all applicable provisions of federal, state and local mechanical/ventilation and construction code, including but not limited to section C403.2.6.1 of ECCCNYS and NYCECC and section 402 of NYS and NYC Mechanical Code (IMC). Deemed savings factors associated with the heating side of heat pumps are under development and will be included in a future revision.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{SF}{1{,}000} \times ESF_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = \frac{SF}{1{,}000} \times ESF_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
SF	= Total square footage of the conditioned space impacted by the measure
$ESF_{cooling}$	= Energy savings factor for cooling (kWh/1,000 ft^2)
$ESF_{heating}$	= Energy savings factor for heating (therms/1,000 ft^2)
1,000	= Conversion to 1,000 ft^2

Summary of Variables and Data Sources

Variable	Value	Notes
SF		From application.
$ESF_{cooling}$		Lookup from $ESF_{cooling}$ table below based on location and building type.
$ESF_{heating}$		Lookup from $ESF_{heating}$ table below based on location and building type.

$ESF_{cooling}$ [1]

kWh/1,000 ft²							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	273	176	248	181	555	292	262
Office - Mid-rise (4 to 11 Stories)	258	166	235	171	525	276	248
Office - High-rise (12+ Stories)	269	174	245	178	548	288	259
Religious Building	305	196	277	202	620	326	292
Restaurant	308	199	280	204	627	330	296
Retail - Department Store	374	241	340	248	761	400	359
Retail - Strip Mall	225	145	205	149	458	241	216
Convenience Store	361	233	328	239	734	386	346
Elementary School	196	126	178	130	398	209	188
High School	189	122	172	125	385	202	182
College/ University	245	158	223	163	499	262	236
Healthcare Clinic	214	138	195	142	436	229	206
Lodging (Hotel/Motel)	346	223	315	229	704	370	332
Manufacturing	289	186	262	191	587	309	277
Special Assembly Auditorium	256	165	232	169	520	273	245
Other	274	177	249	182	558	293	263

$ESF_{heating}$ [2]

Therms/1,000 ft²							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	29	31	29	22	20	19	29
Office - Mid-rise (4 to 11 Stories)	19	21	19	14	13	12	19
Office - High-rise (12+ Stories)	26	28	25	20	18	17	26
Religious Building	189	204	187	144	131	123	189
Restaurant	136	147	135	104	95	89	137
Retail - Department	47	51	47	36	33	30	47

[1] Deemed savings calculated based on IL TRM values for Chicago, adjusted by the ratio of Cooling Degree Days for each listed NY city and Chicago.
[2] Deemed savings calculated based on IL TRM values for Chicago, adjusted by the ratio of Heating Degree Days for each listed NY city and Chicago.

Therms/1,000 ft^2							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Store							
Retail - Strip Mall	30	33	30	23	21	20	30
Convenience Store	23	25	23	18	16	15	24
Elementary School	82	88	81	62	57	53	82
High School	79	86	79	61	55	52	80
College/ University	158	170	156	120	109	102	158
Healthcare Clinic	56	60	55	43	39	36	56
Lodging (Hotel/Motel)	26	28	25	20	18	17	26
Manufacturing	21	23	21	16	15	14	21
Special Assembly Auditorium	221	239	219	169	154	144	222
Other	76	82	75	58	53	49	76

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline system is an existing natural gas heated return air system with no demand control ventilation or ventilation heat recovery equipment installed.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a DCV system added to the return air system to supply air based on occupancy demands.

Operating Hours

N/A

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ECCCNYS 2016, per IECC 2015; C403.2.6 Ventilation
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016; C403.2.6 Ventilation
   Available from: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
3. IMC NYS 2015; 402 Natural Ventilation
   Available from: https://codes.iccsafe.org/public/document/IMC2015NY-1/chapter-4-ventilation
4. IMC NYC 2014: 402 Natural Ventilation
   Available from: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_MC_Chapter4_Ventilation.pdf&section=conscode_2014
5. $ESF_{cooling}$ and $ESF_{heating}$ factors were calculated from the IL TRM values of Chicago by creating a ratio of Cooling/Heating Degree Days between the NY weather cities and Chicago CDD/HDD and multiplying by the Chicago $SF_{cooling}/SF_{heating}$ respectively

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6-17-15	6/30/2017
6-18-11	6/26/2018

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BOILER TUNE-UP

Measure Description

This measure covers tune-up of residential natural gas space heating boilers to improve seasonal heating efficiency. A tune-up involves the inspection, cleaning, and/or adjustment of boiler and appurtenances per manufacturer's recommendations. This measure addresses tune-up benefits associated with heating performance in single family or low-rise multifamily buildings only. For boiler tune-up in high-rise multifamily buildings, see Commercial Boiler Tune-Up measure.

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

$$\Delta therms = units \times \frac{kBTUh_{in}}{unit} \times \frac{EFLH_{heating}}{100} \times ESF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$kBTUh_{in}$	= Nameplate capacity gas input rating (kBTU/h)
$EFLH_{heating}$	= Equivalent full-load heating hours
ESF	= Energy savings factor
100	= Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{in}$		From application.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
ESF	0.03	The energy savings factor for boiler tune-ups is used to estimate the annual heating energy savings.[1]

[1] Energy savings on the order of 2% - 5% were realized from a boiler tune-up program in the Pacific Northwest. Building Tune-Up and Operations Program Evaluation. Washington State University Energy Program, pg. 5.

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 residential gas-fired space heating boiler in a single family or low-rise multifamily building that has not received a tune-up in 5 years or more.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential gas-fired boiler that has undergone a tune-up in accordance with the manufacturer's recommendations.

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.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Improved boiler efficiency as a result of a boiler tune-up will reduce the run time of the distribution system's circulator pumps and boiler combustion fan if so equipped. These effects are anticipated to be small and are not currently quantified for this measure.

References

1. Dethman and Kunkle, Building Tune-Up and Operations Program Evaluation. Washington State University Energy Program, 2007.
   Available from: https://library.cee1.org/system/files/library/1808/990.pdf

Record of Revision

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6-18-15	6/26/2018

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STEAM TRAP REPAIR OR REPLACEMENT – LOW PRESSURE SPACE HEATING

Measure Description

This measure covers the repair or replacement of steam traps in low-pressure (≤15 psig) 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.

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

$$\Delta therms = Loss_{steam} \times \frac{H_v}{Eff} \times \frac{EFLH_{heating}}{100{,}000}$$

$$Loss_{steam} = 24.24 \times Dia^2 \times P_a \times 50\%$$

$$P_a = psig + psia$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherm	= Annual gas energy savings
$Loss_{steam}$	= Hourly steam loss per failed trap (lb/hr)
24.24	= Steam loss constant per Napier's equation (lb/hr-psia-in^2)
Dia	= Internal Diameter (I.D.) of steam trap orifice (inches)
P_a	= Absolute steam pressure (psi)

50% = Percent of orifice open[1]
psig = Steam gage pressure (psi)
psia = Atmospheric pressure (psi)
H_v = Heat of vaporization (latent heat), in Btu/lb, at system operating pressure (psig)
Eff = Efficiency of boiler
$EFLH_{heating}$ = Equivalent full-load heating hours
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$		Calculated per the equation above, dependent upon system operating pressure (psig) and steam trap orifice diameter (Dia).
Dia		Steam trap orifice diameter (in), from application
P_a		Calculated per the equation above, dependent upon system operating pressure (psig).
psig		Steam boiler operating pressure (psi), from application
psia	14.7	Atmospheric pressure (psi)
H_v		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.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.

Heat of Vaporization (Btu/lb)[2]

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

[1] Conservative estimate typically used by steam trap manufacturers/vendors to estimate savings; Enbridge adjustment factor used as referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012 and DOE Federal Energy Management Program Steam Trap Performance Assessment.
[2] Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases (1936)

Pressure (psig)	Heat of Vaporization (Btu/lb)
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 steam trap failed open 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.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 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

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6-18-16	6/26/2018

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POOL PUMP

Measure Description

This measure covers the installation of ENERGY STAR® qualified multi-speed and variable frequency drive (VFD) residential pool pumps. Pool pump speeds vary based on the pool's operation. Filtration, for example, only requires half the flow rate of running a pool cleaner. Conventional pool pumps, with only one speed, are set to run at the higher speeds required of the pool cleaner and waste energy during filtration operation by running faster than necessary. An ENERGY STAR® certified pool pump can run at different speeds and be programmed to match the pool operation with its appropriate pool pump speed. The energy saved is considerable; reducing pump speed by one-half allows the pump to use just one-eighth as much energy.[1] Qualifying pumps have an energy factor of 3.80 gallons per watt-hour or greater.[2] Pool pumps that have earned this label use up to 70% less energy than non-qualified models.[3]

This measure is not applicable to community pools in multifamily housing complexes. This measure is only applicable to in ground pool pumps with a total horsepower rating between 0.75 and 3 HP and with 2- or 2.5-inch diameter piping. While single-speed pumps are eligible under ENERGY STAR® criteria, this measure is only applicable to multi-speed and VFD pumps.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\frac{GPM_{baseline} \times hrs_{baseline}}{EF_{baseline}} - \frac{GPM_{ee,HS} \times hrs_{ee,HS}}{EF_{ee,HS}} - \frac{GPM_{ee,LS} \times hrs_{ee,LS}}{EF_{ee,LS}} \right] \times \frac{60 \times days}{1{,}000}$$

Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{hrs_{annual}} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings

[1] ENERGY STAR® Pool Pumps
https://www.energystar.gov/products/other/pool_pumps
[2] ENERGY STAR® Program Requirements Product Specification for Pool Pumps, Eligibility Criteria Version 1.1, March 2015
[3] ENERGY STAR® Pool Pump Fact Sheet, January 2018

Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
GPM	= Gallons per minute
$_{HS}$	= High speed operation
$_{LS}$	= Low speed operation
hrs	= Hours of operation per day
EF	= Energy factor (Gal/Wh)
days	= Number of operating days per day
hrs_{annual}	= Annual hours of operation
60	= Conversion factor, minutes per hour
1,000	= Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$		Look up in Baseline Efficiencies section below, based on pool curve and nameplate hp.
$GPM_{ee,HS}$		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.
$GPM_{ee,LS}$		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.
$hrs_{baseline}$		From application. If unknown, use 11.4 as default.[4]
$hr_{ee,HS}$		From application. If unknown, use 2 as default.[5]
$hr_{ee,LS}$		From application. If unknown, use 10 as default.[6]
$EF_{baseline}$		Look up in Baseline Efficiencies section below, based on pool curve and nameplate hp.
$EF_{ee,HS}$		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.
$EF_{ee.LS}$		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.
days		From application. If unknown, use 122 as default, based on 4 months of operation per year.
hrs_{annual}		From application. If unknown, use 1,464 as default, based on 12 hours of operation per day, 122 days per year.

Default Values

The table below contains values for annual electric energy savings and peak coincident demand savings. These values were established by using the assumed values from the Summary of Variables and Data Sources table above. Default values additionally assume a 22,000-gallon pool, 2-inch diameter piping, a 1.5 hp baseline pump, and a 1.0 hp qualifying pump.

[4] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 5/15/2018)
[5] Ibid.
[6] Ibid.

Pump Type	ΔkWh	ΔkW
Multi-Speed	1,781	0.343
VFD	2,041	0.393

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.282.[7]

Baseline Efficiencies from which Incentives are Calculated

The baseline condition is a non-ENERGY STAR® qualified single-speed pool pump. The values for baseline energy factor and GPM are found in the table below, based on nameplate horsepower and pump curve. The pump curve compares the total head in feet of water to the flow rate of the water for a given pump at a given motor speed. For a system with 2-inch diameter piping, use Curve A designation values. For a system with 2.5-inch diameter piping, use Curve C designation values.

Pump Type and Variable	Nameplate Horsepower						
	3	2.5	2	1.5	1	0.75	0.5
Curve A – $EF_{baseline}$	1.6	1.9	1.9	2.1	2.4	2.6	2.7
Curve A – $GPM_{baseline}$	73	68	65	64	60	53	50
Curve C – $EF_{baseline}$	2.0	2.2	2.3	2.3	2.5	3.3	3.4
Curve C – $GPM_{baseline}$	102	93	89	78	76	65	62

Compliance Efficiency from which Incentives are Calculated

Multi-Speed Pumps

The compliance condition is an ENERGY STAR® qualified multi-speed inground pool pump. Typical energy factor and flow rate at high and low speeds for ENERGY STAR® multi-speed pool pumps are found in the table below, based on nameplate horsepower and pump curve. The pump curve compares the total head in feet of water to the flow rate of the water for a given pump at a given motor speed. For a system with 2-inch diameter piping, use Curve A designation values. For a system with 2.5-inch diameter piping, use Curve C designation values.

Pump Type and Variable	Nameplate Horsepower at High Speed					
	3	2.5	2	1.5	1	0.75
Curve A – $EF_{ee,HS}$	1.6	2.0	2.0	2.3	2.4	2.5
Curve A – $GPM_{ee,HS}$	74.0	66.0	66.4	61.0	56.0	56.0
Curve A - $EF_{ee,LS}$	4.8	4.8	5.2	5.4	5.4	6.6
Curve A - $GPM_{ee,LS}$	37.0	34.0	33.3	31.9	31.0	29.0
Curve C - $EF_{ee,HS}$	2.0	2.4	2.4	2.7	3.0	3.16
Curve C - $GPM_{ee,HS}$	102.0	90.0	89.7	78.0	70.0	73.0
Curve C - $EF_{ee,LS}$	6.1	6.0	6.5	6.7	6.8	8.3

[7] Southern California Edison, Pool Pump Demand Response Potential; Demand and Run-Time Monitored Data, June 2008, Table 16 "Average Hourly kW Demand Profiles by SCE Region"

Pump Type and Variable	Nameplate Horsepower at High Speed					
	3	**2.5**	**2**	**1.5**	**1**	**0.75**
Curve C - $GPM_{ee,LS}$	51.0	45.7	44.8	41.8	40.3	37.0

Variable Frequency Drive Pumps

The compliance condition is an ENERGY STAR® qualified VFD inground pool pump. Typical flow rate at high and low speeds for ENERGY STAR® VFD pool pumps is described in the table below.

Pool Pump Speed	Flow rate
$GPM_{ee,LS}$	$\frac{v}{hrs_{turnover} \times 60}$
$GPM_{ee,HS}$	50

where:

v = Pool volume (gallons)

$hrs_{turnover}$ = Hours for pump to cycle through pool water. If unknown, use 12 as default.

60 = Conversion factor, minutes per hour

Typical energy factor for high and low speeds for ENERGY STAR® VFD pool pumps is derived from the equations below based on the flow rate at each speed and pump curve type. Develop both $EF_{ee,HS}$ and $EF_{ee,LS}$ from the equations below with $GPM_{ee,HS}$ and $GPM_{ee,LS}$ inputs, respectively. For a system with 2-inch diameter piping, use Curve A designation values. For a system with 2.5-inch diameter piping, use Curve C designation values.

Pool Curve Type	EF_{ee}
Curve A	$EF_{ee} = 20.554\ e^{-0.034 \times GPM_{ee}}$
Curve C	$EF_{ee} = 27.188\ e^{-0.026 \times GPM_{ee}}$

Operating Hours

Based on New York's average climate, it is assumed that a pool is in use for 4 months per year.[8] While in use, the energy efficient pump cycles through pool water at a default rate of 12 hours.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

[8] It is assumed that 50% of pools are unheated and operate for 3 months per year and the other 50% of pools are heated and operate for 5 months per year, giving an average of 4 months of usage per year

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements Product Specification for Pool Pumps, Eligibility Criteria Version 1.1, March 2015
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Pool%20Pumps%20-%20Program%20Requirements%20Version%201.1.pdf
2. ENERGY STAR® Pool Pump Fact Sheet, January 2018
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/PoolPumps_FactSheet_012318_0.pdf
3. Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps, December 2013
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/Pool%20Pump%20Calculator.xlsx
4. Southern California Edison, Pool Pump Demand Response Potential; Demand and Run-Time Monitored Data, June 2008
   Available from: https://www.etcc-ca.com/sites/default/files/reports/dr07_01_pool_pump_demand_response_potential_report.pdf

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DISHWASHER

Measure Description

This measure covers the installation of ENERGY STAR® qualified electric commercial dishwashers.[1] A dishwasher is a machine designed to clean and sanitize plates, pots, pans, glasses, cups, bowls, utensils, and trays by applying sprays of detergent solution (with or without blasting media granules) and a sanitizing rinse. ENERGY STAR® rated machines consume less water and use less energy while idling between wash cycles. Commercial dishwashers that have earned the label are about 40% more energy efficient than comparable un-qualified models.[2]

This measure applies to stationary rack machines and conveyor machines operating at low or high temperatures. This measure is not applicable to flight machines, which are custom-built, continuous conveyor machines designed for use in large institutions.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times [(\Delta kWh_{wh} \times ElecSF_{wh}) + (\Delta kWh_{booster} \times ElecSF_{booster}) + \Delta kWh_{idle}]$$

Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{hrs} \times F_{peak} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times [(\Delta therms_{wh} \times GasSF_{wh}) + (\Delta therms_{booster} \times GasSF_{booster})]$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
ΔkWh_{wh}	= Annual electric water heating energy savings
$\Delta kWh_{booster}$	= Annual electric booster water heater energy savings
ΔkWh_{idle}	= Annual electric dishwasher idle energy savings
$ElecSF_{wh}$	= Electric Savings Factor for water heaters
$ElecSF_{booster}$	= Electric Savings Factor for booster water heaters
$\Delta therms_{wh}$	= Annual gas water heating energy savings
$\Delta therms_{booster}$	= Annual gas booster water heater energy savings
$GasSF_{wh}$	= Gas Savings Factor for water heaters

[1] ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers Eligibility Criteria Version 2.0, February 2013

[2] Efficiency of ENERGY STAR® products: https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers

$GasSF_{booster}$ = Gas Savings Factor for booster water heaters
hrs = Annual hours of operation
F_{peak} = Peak operation factor; binary variable to indicate whether equipment operates during electric system peak (summer weekday hour ending at 5PM)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh_{wh}		Look up based on Dishwasher Type in Default Values table below.
$\Delta kWh_{booster}$		Look up based on Dishwasher Type in Default Values table below.
ΔkWh_{idle}		Look up based on Dishwasher Type in Default Values table below.
$ElecSF_{wh}$	Electric WH: 1 Non-Electric WH: 0	
$ElecSF_{booster}$	Electric Booster: 1 Non-Electric Booster: 0	
$\Delta therm_{wh}$		Look up based on Dishwasher Type in Default Values table below.
$\Delta therm_{booster}$		Look up based on Dishwasher Type in Default Values table below.
$GasSF_{wh}$	Non-Gas WH: 0 Gas WH: 1	
$GasSF_{booster}$	Non-Gas Booster: 0 Gas Booster: 1	
hrs		From application. Default values use 6,570 which assumes 18 hours of run time per day, 365 days per year
F_{peak}	Peak Operation: 1 No Peak Operation: 0	From application.
CF	0.9	

Default Values[3]

Dishwasher Type	Elec. DHW (ΔkWh_{wh})	Gas DHW ($\Delta therm_{wh}$)	Elec. Booster ($\Delta kWh_{booster}$)	Gas Booster ($\Delta therm_{booster}$)	Dishwasher (ΔkWh_{idle})
Low Temp, Under Counter	2,540	106	N/A	N/A	0
Low Temp, Stationary Single Tank Door	16,153	675	N/A	N/A	0

[3] Deemed savings based on default values listed in Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)

Low Temp, Single Tank Conveyor	13,042	545	N/A	N/A	584
Low Temp, Multi-Tank Conveyor	18,811	786	N/A	N/A	0
High Temp, Under Counter	1,082	45	618	26	1,471
High Temp, Stationary Single Tank Door	7,023	294	4,013	168	827
High Temp, Single Tank Conveyor	4,264	178	2,436	102	2,511
High Temp, Multi-Tank Conveyor	16,178	676	9,244	386	1,986
High Temp, Pot, Pan, and Utensil	2,107	88	1,204	50	0

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.9.[4]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a commercial dishwasher as defined in the Measure Description section above with type equivalent to the proposed case. Baseline specifications for idle energy rate, measured in kW, and water consumption, measured in gallons per rack (GPR), used in the formulation of default savings values are provided in the table below.[5]

Machine Type	High Temp		Low Temp	
	Idle Energy Rate (kW)	Water Consumption (GPR)	Idle Energy Rate (kW)	Water Consumption (GPR)
Under Counter	≤ 0.76	≤ 1.09	≤ 0.50	≤ 1.73
Stationary Single Tank Door	≤ 0.87	≤ 1.29	≤ 0.60	≤ 2.10
Single Tank Conveyor	≤ 1.93	≤ 0.87	≤ 1.60	≤ 1.31
Multiple Tank Conveyor	≤ 2.59	≤ 0.97	≤ 2.00	≤ 1.04
Pot, Pan, Utensil	≤ 1.20	≤ 0.70	N/A	N/A

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® rated commercial dishwasher as defined in the Measure Description section above. Compliance specifications for idle energy rate, measure in

[4] PG&E Work Paper PGECOFST126 Revision 0, Table 10, pg. 18
[5] Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)

kW, and water consumption, measured in gallons per rack (GPR) used in the formulation of default savings values are provided in the table below.[6]

Machine Type	High Temp		Low Temp	
	Idle Energy Rate (kW)	Water Consumption (GPR)	Idle Energy Rate (kW)	Water Consumption (GPR)
Under Counter	≤ 0.50	≤ 0.86	≤ 0.50	≤ 1.19
Stationary Single Tank Door	≤ 0.70	≤ 0.89	≤ 0.60	≤ 1.18
Single Tank Conveyor	≤ 1.50	≤ 0.70	≤ 1.50	≤ 0.79
Multiple Tank Conveyor	≤ 2.25	≤ 0.54	≤ 2.00	≤ 0.54
Pot, Pan, Utensil	≤ 1.20	≤ 0.58	N/A	N/A

Operating Hours

Operating hours shall come from application. Default savings assumes that dishwashers are available for operation 18 hours per day, 365 days per year.[7]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements for Commercial Dishwashers Eligibility Criteria Version 2, February 2013
   Available From:
   https://www.energystar.gov/ia/products/commercial_food_service/comm_dishwashers/Final_Comm_Dish_Spec.pdf
2. ENERGY STAR® Certified Products, Commercial Food Service Equipment, Commercial Dishwashers
   Available from:
   https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers
3. Pacific Gas & Electric Company, Work Paper PGECOFST126 Energy Efficient Door-

[6] Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)
[7] Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)

Type Commercial Dishwashers, Revision 0, November 2015
Available from: www.deeresources.net/workpapers

4. Savings calculator for ENERGY STAR® Commercial Kitchen Equipment
Available from:
http://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

Record of Revision

Record of Revision Number	Issue Date
6-18-18	6/26/2018

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ICE MAKER

Measure Description

This measure covers the installation of ENERGY STAR® qualified ice makers in commercial applications.[1] Ice makers are factory-made assemblies consisting of a condensing unit and ice-making section operating as an integrated unit, with means for making and harvesting ice. This measure includes batch-type (cube type) and continuous-type (flake or nugget type) ice makers. Batch-type ice makers have distinct freezing and harvesting periods whereas continuous-type ice makers produce ice through a continuous freezing and harvesting process. Ice makers that have earned the ENERGY STAR® label use approximately 11% less energy and 25% less water than comparable non-qualified models.[2]

This measure covers ice making head, remote condensing, and self-contained air-cooled ice makers. Water-cooled ice makers, ice and water dispensing systems, and air-cooled remote condensing units that are designed only for connection to remote rack compressors are not eligible for savings claims.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_{baseline} - kWh_{ee}) \times 365 \times Cycle \times (IHR/100)$$

Peak Coincident Demand Savings

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

Annual Natural Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual natural gas energy savings
units	= Number of measures installed under the program
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
kWh	= Daily electric energy consumption per 100 pounds of ice
Cycle	= Compressor duty cycle
IHR	= Rated Ice Harvest Rate (lbs/day) of the energy efficient ice maker
CF	= Coincidence factor

[1] ENERGY STAR® Program Requirements Product Specification for Automatic Commercial Ice Makers Eligibility Criteria Version 3.0, January 2018
[2] ENERGY STAR® Ice Machine Key Product Criteria

365 = Days in one year
100 = Factor to convert IHR to units of 100 lbs/day
8,760 = Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		Look up based on proposed Equipment Type and Ice Harvest Rate from Baseline Efficiency section below.
kWh_{ee}		From application. If unknown, look up based on proposed Equipment Type and Ice Harvest Rate from Compliance Efficiencies section below.
IHR		Rated capacity of efficient ice maker from application.
Cycle	0.75[3]	Compressor duty cycle.
CF	0.9	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.9.[4]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a commercial ice maker as defined in the Measure Description section above with Equipment Type and Ice Harvest Rate equivalent to the proposed case. Baseline daily energy use per 100 lbs of ice shall be established based on proposed equipment Ice Harvest Rate in accordance with current federal standards for batch type[5] and continuous type[6] ice makers, as specified in the Code of Federal Regulations and provided in the table below.

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs ($kWh_{baseline}$)
Batch Type, Ice-Making Head	< 300	10 - 0.01233 x IHR
Batch Type, Ice-Making Head	≥ 300 and < 800	7.05 - 0.0025 x IHR
Batch Type, Ice-Making Head	≥ 800 and < 1,500	5.55 - 0.00063 x IHR
Batch Type, Ice-Making Head	≥ 1500 and < 4,000	4.61
Batch Type, Remote Condensing	< 988	7.97 - 0.00342 x IHR
Batch Type, Remote Condensing	≥ 988 and < 4,000	4.59
Batch Type, Self-Contained	< 110	14.79 - 0.0469 x IHR
Batch Type, Self-Contained	≥ 110 and < 200	12.42 - 0.02533 x IHR
Batch Type, Self-Contained	≥ 200 and < 4,000	7.35
Continuous Type, Ice-Making Head	< 310	9.19 - 0.00629 x IHR
Continuous Type, Ice-Making Head	≥ 310 and < 820	8.23 - 0.0032 x IHR

[3] PG&E Work Paper PGECOFST108, Revision 5, pg 9
[4] PG&E Work Paper PGECOFST108, Revision 5, pg 12
[5] 10 CFR 431.136 (c)
[6] 10 CFR 431.136 (d)

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs ($kWh_{baseline}$)
Continuous Type, Ice-Making Head	≥ 820 and < 4,000	5.61
Continuous Type, Remote Condensing	< 800	9.7 - 0.0058 x IHR
Continuous Type, Remote Condensing	≥ 800 and < 4,000	5.06
Continuous Type, Self-Contained	< 200	14.22 - 0.03 x IHR
Continuous Type, Self-Contained	≥ 200 and < 700	9.47 - 0.00624 x IHR
Continuous Type, Self-Contained	≥ 700 and < 4,000	5.1

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified commercial ice maker as defined in the Measure Description above. Proposed daily energy use per 100 pounds of ice are established based on proposed equipment Ice Harvest Rate in accordance with ENERGY STAR® maximum qualifying specifications, as shown in the table below.[7]

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs (kWh_{ee})	Potable Water Use (gal/100 lbs ice)
Batch Type, Ice-Making Head	< 300	9.20 - 0.01134 x IHR	≤ 20.0
Batch Type, Ice-Making Head	≥ 300 and < 800	6.49 - 0.0023 x IHR	≤ 20.0
Batch Type, Ice-Making Head	≥ 800 and < 1,500	5.11 - 0.00058 x IHR	≤ 20.0
Batch Type, Ice-Making Head	≥ 1500 and < 4,000	4.24	≤ 20.0
Batch Type, Remote Condensing	< 988	7.17 - 0.00308 x IHR	≤ 20.0
Batch Type, Remote Condensing	≥ 988 and < 4,000	4.13	≤ 20.0
Batch Type, Self-Contained	< 110	12.57 - 0.0399 x IHR	≤ 25.0
Batch Type, Self-Contained	≥ 110 and < 200	10.56 - 0.0215 x IHR	≤ 25.0
Batch Type, Self-Contained	≥ 200 and < 4,000	6.25	≤ 25.0
Continuous Type, Ice-Making Head	< 310	7.90 - 0.005409 x IHR	≤ 15.0
Continuous Type, Ice-Making Head	≥ 310 and < 820	7.08 - 0.002752 x IHR	≤ 15.0
Continuous Type, Ice-Making Head	≥ 820 and < 4,000	4.82	≤ 15.0
Continuous Type, Remote Condensing	< 800	7.76 - 0.00464 x IHR	≤ 15.0
Continuous Type, Remote Condensing	≥ 800 and < 4,000	4.05	≤ 15.0

[7] ENEGY STAR® Program Requirements Product Specification for Automatic Commercial Ice Makers, Eligibility Criteria Version 3.0, January 2018

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs (kWh_{ee})	Potable Water Use (gal/100 lbs ice)
Continuous Type, Self-Contained	< 200	12.37 - 0.0261 x IHR	≤ 15.0
Continuous Type, Self-Contained	≥ 200 and < 700	8.24 - 0.005429 x IHR	≤ 15.0
Continuous Type, Self-Contained	≥ 700 and < 4,000	4.44	≤ 15.0

Operating Hours

Commercial ice makers are assumed to be available for operation 24 hours per day, 365 days per year with a compressor duty cycle of 0.75.[8]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Efficient ice makers reject less heat than standard equipment, increasing space heating requirements while decreasing cooling load, when located inside a conditioned area. However, this interactivity is considered negligible for the installation of an air-cooled ice maker and is not included in the energy savings calculation.

Ancillary Electric Savings Impacts

Efficient ice makers reject less heat than standard equipment, increasing space heating requirements while decreasing cooling load, when located inside a conditioned area. However, this interactivity is considered negligible for the installation of an air-cooled ice maker and is not included in the energy savings calculation.

References

1. ENERGY STAR® Program Requirements Product Specification for Automatic Commercial Ice Makers Eligibility Criteria Version 3.0, January 2018
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/Final%20V3.0%20ACIM%20Specification%205-17-17_1_1.pdf
2. ENERGY STAR® Certified Products, Commercial Ice Makers
   Available from:
   https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers

[8] PG&E Work Paper PGECOFST108, Revision 5, pg 9

3. Pacific Gas & Electric Work Paper PGECOFST108 Commercial Ice Machines, Revision 5, August 2016
   Available from: www.deeresources.net/workpapers
4. 10 CFR 431.136 Energy conservation standards and their effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=62fc415d2221a3b1166362f5a2949044&mc=true&node=sp10.3.431.h&rgn=div6#se10.3.431_1136

Record of Revision

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6-18-19	6/26/2018

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INSTANTANEOUS WATER HEATER

Measure Description

This measure covers the installation of high-efficiency gas and electric instantaneous water heaters, which heat water but contain no more than one gallon of water per 4,000 BTU per hour of input. It is applicable to gas-fired instantaneous water heaters with a rated input greater than 200,000 BTU per hour and electric instantaneous water heaters with a rated input greater than 12 kW.[1] This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating.

This measure applies to replacement of existing storage type water heaters using the same heating fuel (gas or electric) as the proposed case. For new construction, this measure assumes baseline to be a standard efficiency water heater using the same heating fuel (gas or electric) as the proposed case.

This measure applies to commercial grade water heaters only. For residential-duty water heaters installed in commercial settings, the Residential Storage Tank and Instantaneous Domestic Water Heater methodology detailed in this document shall be employed utilizing typical GPD values as defined in the "Gallons per Day (GPD)" section below.

Method for Calculating Annual Energy and Peak Coincidence Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}}\right) + \frac{UA_{baseline} \times \Delta T_{amb} \times 8{,}760}{E_{t,baseline} \times 3{,}412}\right]$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{UA_{baseline} \times \Delta T_{amb}}{3{,}412} \times CF$$

Annual Gas Energy Savings

$$\Delta therm = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}}\right) + \frac{UA_{baseline} \times \Delta T_{amb} \times 8{,}760}{E_{t,baseline} \times 100{,}000}\right]$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherm	= Annual gas energy savings
units	= Number of measures installed under the program
GPD	= Gallons per day
ΔT_{main}	= Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)

[1] 10 CFR 431.102

ΔT_{amb} = Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
E_t = Thermal efficiency
UA = Overall heat loss coefficient (BTU/hr-°F)
CF = Coincidence factor
365 = Days in one year
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU
8,760 = Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
GPD		From application, or lookup based on building type in GPD table below.
ΔT_{main}	T_{set} - T_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	(T_{set} - T_{amb})	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
T_{set}		Water heater set point temperature (°F). From application, or use 140°F.[2]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
T_{amb}	70	Surrounding ambient air temperature (°F). [3]
$E_{t,baseline}$	Electric – 0.98 Gas – 0.80	Thermal efficiency of the baseline condition[4,5]
$E_{t,ee}$		Thermal efficiency for energy efficient measure, from application
$UA_{baseline}$		Overall heat loss coefficient of the baseline condition, calculate based on baseline standby loss per the Overall Heat Loss Coefficient section below.

[2] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/dts/osta/otm/legionnaires/hotwater.html)
[3] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.
[4] Gas: 10 CFR 431.110 (a)
[5] Electric: Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

Gallons per Day (GPD)

The average daily hot water usage, expressed in gallons per day, for several commercial facility types is tabulated below. Daily hot water usage can be calculated based on the GPD and site-specific metric in the Rate column, or default values can be referenced directly from the GPD column.

Building Type	GPD	Rate	Notes/Assumptions	Source
Assembly	239	7.02 GPD per 1,000 SF	Assumes 10% hot water, 34,000 SF	EIA[6]: Public Assembly
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 10% hot water, 5,150 SF	EIA: Other
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 10% hot water, 130,500 SF	EIA: Mercantile
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL[7]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation[8]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC[9]: Quick Service
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service
Grocery	172	3.43 GPD per 1,000 SF	Assumes 10% hot water, 50,000 SF	EIA: Mercantile
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 40% hot water, 250,000 SF	EIA: Health Care, Inpatient
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 10% hot water, 130,000 SF	EIA: Mercantile
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 10% hot water, 100,000 SF	EIA: Other
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 40% hot water, 30,000 SF	EIA: Lodging
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 10% hot water, 92,000 SF	EIA: Warehouse and Storage
Religious	77	7.02 GPD per 1,000 SF	Assumes 10% hot water, 11,000 SF	EIA: Public Assembly
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 10% hot water, 8,000 SF	EIA: Mercantile
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 10% hot water, 500,000 SF	EIA: Warehouse and Storage
Other	Calculate	4.89 GPD per 1,000 SF	Assumes 10% hot water	EIA: Other

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[10] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[11] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3

[6] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012

[7] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011

[8] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016

[9] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

[10] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory

[11] Average annual outdoor temperatures taken from NCDC 1981-2010 climate normals

City	Annual average outdoor temperature[11] (°F)	T_{main} (°F)
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Overall Heat Loss Coefficient ($UA_{baseline}$)

Tank overall heat loss coefficient is calculated from the equipment standby loss specification. To calculate $UA_{baseline}$, use the appropriate intermediate standby loss equation from the Baseline Standby Losses section below.

$$UA = \frac{SL}{70}$$

where:

SL = Standby heat loss (BTU/hr). For the baseline condition ($SL_{baseline}$), use the appropriate intermediate standby loss equation from the Baseline Standby Losses section below.

70 = Temperature difference associated with standby loss specification (°F)[12]

Baseline Standby Losses ($SL_{baseline}$)

Standby losses ($SL_{baseline}$) for large electric storage type water heaters (> 12kW and > 20 gallons):[13]

$$SL_{baseline} = 20 + 35\sqrt{v_{baseline}}$$

where:

$v_{baseline}$ = Baseline tank volume (gal). If unknown, assume 150 gallons.

Standby losses ($SL_{baseline}$) for large gas storage type water heaters (> 75,000 BTU/hr input capacity (Q) and storage size > 1 gallon per 4000 BTU/hr):[14]

$$SL_{baseline} = \frac{Q_{baseline}}{800} + 110\sqrt{v_{baseline}}$$

where:

$v_{baseline}$ = Baseline tank volume (gal). If unknown, assume 150 gallons.

$Q_{baseline}$ = Baseline input capacity (BTU/hr). If unknown, assume 200,000 BTU/hr.

[12] 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters

[13] Ibid.

[14] Ibid.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8[15]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard efficiency gas or electric storage type water heater (fuel type equivalent to the proposed case) with tank volume and input capacity equivalent to those of the existing equipment, UA value calculated as prescribed above and a thermal efficiency of 0.80 (gas) or 0.98 (electric). If tank volume and input capacity are unknown, assume the baseline condition consists of a 150-gallon storage type water heater with an input capacity of 200,000 BTU/hr.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a gas or electric instantaneous water heater as defined in the Measure Description section above. Gas tankless water heaters must meet the minimum qualifying efficiency for ENERGY STAR® certification of a thermal efficiency greater than or equal to 0.94.[16] Electric tankless water heaters must meet or exceed the efficiency of the baseline condition with a thermal efficiency greater than or equal to 0.98.

Effective Useful Life (EUL)

See Appendix P.

Operating Hours

Water heater run hours are not utilized in the estimation of energy or demand savings, but water heater is assumed to be available for operation 8,760 hours per year. Additionally, it is assumed standby losses are incurred 8,760 hours per year in the baseline case.

Ancillary Fossil Fuel Savings Impacts

Reduction in standby heat losses will have a negligible impact on space heating when the water heater is located in a conditioned space. Consideration of these effects is not included in this methodology.

Ancillary Electric Savings Impacts

Reduction in standby heat losses will have a negligible impact on space heating and cooling when the water heater is located in a conditioned space. Consideration of these effects is not included in this methodology.

[15] *No source specified – update pending availability and review of applicable references.*
[16] ENERGY STAR® Commercial Water Heater Key Product Criteria

References

1. 10 CFR 431.102 Definitions concerning commercial water heaters, hot water supply boilers, unfired hot water storage tanks, and commercial heat pump water heaters.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=863517ec5f69fb78dad68864aa84c128&mc=true&n=sp10.3.431.g&r=SUBPART&ty=HTML#se10.3.431_1102
2. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from: https://www.osha.gov/dts/osta/otm/legionnaires/hotwater.html
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   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
4. 10 CFR 431.110 Energy conservation standards and their effective dates
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   Available from: https://www.eia.gov/consumption/commercial/reports/2012/water/
6. National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011
   Available from: https://www.nrel.gov/docs/fy11osti/50118.pdf
7. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016
   Available from: http://www.waterrf.org/PublicReportLibrary/4309A.pdf
8. Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010
   Available from: https://fishnick.com/design/waterheating/Water_Heating_Design_Guide_Final_FNi_disclaimer.pdf
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   Available from: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.515.6885
10. NOAA National Centers for Environmental Information – NCDC 1981-2010 Climate Normals
11. 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters
    Available from: https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf

12. ENERGY STAR® Commercial Water Heater Key Product Criteria
    Available from:
    https://www.energystar.gov/products/water_heaters/commercial_water_heaters/key_product_criteria

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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	Advanced Power Strips	Residential	8	DEER 2014 EUL ID: Plug-OccSens
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Clothes Dryer	Residential	14	ESTAR M&I Scoping Report[1]
	Dehumidifier	Residential	12	ESTAR Calc[2]
	Air Purifier (Cleaner)	Residential	9	ESTAR Calc[3]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Refrigerator Replacement	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
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
Building Shell	Air Leakage Sealing	Residential	15	GDS[4]
	Hot Water Pipe Insulation	Residential	15	GDS[5]
	Opaque Shell Insulation	Residential	30	Energy Trust of Oregon and CEC[6]
	Window & Through-the-Wall AC Cover and Gap Sealer	Residential	5	See note below[7]
	Window Replacement	Residential	20	DEER 2014 EUL ID: BS-Win

[1] ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[2] ENERGY STAR Dehumidifier Calculator https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[3] 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
[4] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[5] Ibid.
[6] http://energytrust.org/library/reports/resource_assesment/gasrptfinal_ss103103.pdf
[7] At least one manufactures warranty period. www.gss-ee.com/products.html

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Domestic Hot Water	Heat Pump Water Heater – Air Source (HPWH)[8]	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	11	DEER 2014 EUL ID: WtrHt-Res-Gas
	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
Domestic Hot Water - Control	Faucet – Low Flow Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Shower Restriction Valve	Residential	10	UPC[9]
	Shower Head – Low Flow	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner and Heat Pump – Refrigerant Charge Correction and Tune-Up	Residential	10	DEER 2014 EUL ID: HV-RefChrg
	Air Conditioner and Heat Pump – Right-Sizing	Residential	15	DEER[10]
	Air Conditioner, Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
	Air Conditioner – Room (RAC)	Residential	12	GDS[11]
	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

[8] Electric heat pump used for service hot water heating

[9] 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.

[10] Savings assumed to persist over EUL of air conditioner or heat pump

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Boiler, Steam – Cast Iron	Residential	30	ASHRAE Handbook, 2015
	Boiler Tune-Up	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Circulator with EC Motor for Hydronic Distribution	Residential	15	DEER 2014 EUL ID: Motors-pump
	Duct Sealing and Insulation	Residential	18	DEER 2014 EUL ID: HV-DuctSeal
	Blower Fan with EC Motor for Furnace Distribution	Residential	15	DEER 2014 EUL ID: Motors fan
	Furnace, Gas Fired	Residential	22	DOE[12,13]
	Furnace Tune-Up	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Heat Pump - Air Source	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source	Residential	25	ASHRAE[14]
	Heat Pump – PTHP	Residential	15	DEER 2014 EUL ID: HVAC-PTHP
	Unit Heater, Gas Fired	Residential	13	ASHRAE Handbook, 2015
HVAC - Control	Outdoor Setback Control for Hydronic Boiler	Residential	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Manufacture)	N/A
	Steam Traps Repair/Replace	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Thermostat – Programmable; Thermostat – Wi-Fi Communicating Thermostat – Learning	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve	Multifamily	15	DOE[15]

[12] 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

[13] 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

[14] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://energy.gov/energysaver/geothermal-heat-pumps

[15] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. Cost-Benefit Financial Assumptions, pg. 16

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Lighting	Compact Fluorescent Lamp (CFL)	Residential	Coupon – 5	GDS
			Direct Inst. – 7	GDS
			Markdown - 7	GDS
		Multifamily Common Area	9,000 hrs/ annual lighting operating hrs	See note below[16]
	LED Lamps (Directional)	Residential/ Multifamily Common Area	25,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR Lamps[17]
			35,000 or 50,000 hours	DLC[18]
	LED Lamps (Decorative & Omnidirectional)	Residential/ Multifamily Common Area	15,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR Lamps

[16] Multi-family common areas tend to have longer run hours than dwelling units. Default value from C&I lighting table is 7,665 hours per year

[17] ENERGY STAR Program Requirements Product Specification for Lamps (Light Bulbs) V2.0, August 2016, p. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2_0%20Revised%20AUG-2016.pdf

[18] Placed on the Qualified Products List by the Design Light Consortium (DLC) 35,000 or 50,000 hours, according to the appropriate Application Category as specified in the DLC's Product Qualification Criteria, Technical Requirement Table version 4.0 or higher

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED (Interior)	Residential/ Multifamily	25,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR Fixtures[19]
		LED (Exterior)	Residential/ Multifamily Common Area	35,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR Fixtures
		Linear Fluorescent	Residential / Multifamily Common Area	70,000 hrs / annual lighting operating hrs, or 20 yrs (whichever is less)	DEER 2014[20] EUL ID: ILtg-Lfluor-CommArea
		CFL	Residential / Multifamily Common Area	22,000 hrs / annual lighting operating hrs, or 20 yrs (whichever is less)	See note below[21]
Lighting Control	Stairwell Dimming Light Fixture/Sensor		Multifamily	12	GDS[22]
Motors	Pool Pumps		Residential	10	DEER 2014 EUL ID: OutD-PoolPump

[19] ENERGY STAR Program Requirements Product Specification for Luminaires (Light Fixtures) V2.0, May 2015, p. 17 (Capped at 20 years). https://www.energystar.gov/sites/default/files/Luminaires%20V2%200%20Final.pdf

[20] Basis value 70,000 hours, capped at 20 years, is common given redecoration patterns

[21] Basis value 22,000 hour ballast life per US EPA. Capped at 20 years as above (2.5 hours per day average lamp operation)

[22] GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural	Engine Block Heater Timer	C&I	8	See note below[23]
Appliance	Advanced Power Strips	C&I	8	DEER 2014 EUL ID: Plug-OccSens
	Clothes Dryer	C&I	14	ESTAR M&I Scoping Report[24]
	Electric & Gas Cooking Equipment	C&I	12	DEER 2014 EUL IDs: Various
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ESTAR Calc[25]
	Room Air Conditioner Recycling	C&I	9	DEER 2014 EUL ID: HV-RAC-ES
	Refrigerator Replacement	C&I	12	DEER
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
Appliance Control	Vending Machine/Novelty Cooler Control	C&I	5	DEER 2014 EUL ID: Plug-VendCtrler
Building Shell	Cool Roof	C&I	15	DEER
	Hot Water Pipe Insulation	C&I	13 – Electric 11 – Natural Gas	DEER
	Window - Film	C&I	10	DEER
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
	Opaque Shell Insulation	C&I	30	ET & CEC[26]
Compressed Air	Air Compressor Upgrade	C&I	13	State TRMs[27]
	Refrigerated Air Dryer	C&I	15	UI and CL&P[28]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[29]
	No Air Loss Water Drain	C&I	15	Ohio TRM[30]

[23] Based on EUL's for similar control technology
[24] ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[25] 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
[26] Energy Trust uses 30 years for commercial applications. http://energytrust.org/library/reports/Residentialource_assesment/gasrptfinal_ss103103.pdf. CEC uses 30 years for insulation in Title 24 analysis
[27] 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.
[28] UI and CL&P, Program Savings Documentation for 2007 Program Year, September 2006, pg. 224
[29] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[30] EUL for this measure not available. Default to air compressor upgrade EUL from Ohio TRM. www.OhioTRM.org

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Domestic Hot Water (DHW)	Indirect Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Storage Tank Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Instantaneous Water Heater	C&I	20	DEER 2014 EUL ID: WtrHt-Instant-Com
	Heat Pump Water Heater - Air Source (HPWH)	C&I	10	DEER
DHW - Control	Faucet – Low Flow Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Showerhead – Low Flow	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Pre-Rinse Spray Valve	C&I	5	GDS
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner and Heat Pump – Refrigerant Charge Correction and Tune-Up	C&I	10	DEER 2014 EUL ID: HVAC-RecChg
	Air Conditioner – Unitary	C&I	15	DEER 2014 EUL ID: HVAC-airAC
	Air Conditioner – PTAC	C&I	15	DEER 2014 EUL ID: HVAC-PTAC
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: ClTwrPkgSys
	Chiller Tune-Up	C&I	5	WI EUL DB[31]
	Combination Boiler and Water Heater	C&I	20	DEER[32]
	Condensing Gas-Fired Unit Heater for Space Heating	C&I	18	Ecotope[33]
	Duct Sealing and Insulation	C&I	18	DEER
	EC Motors on HVAC Equipment	C&I	15	DEER 2014 EUL ID: Motors-Fan
	Economizer – Air Side, with Dual Enthalpy Control	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	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

[31] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[32] Based on DEER value for high efficiency boiler
[33] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Boiler Tune-Up	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Furnace, Gas Fired	C&I	23	DOE[34],[35]
	Unit Heater, Gas Fired	C&I	13	ASHRAE Handbook, 2015
	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
	Infrared Gas Space Heater	C&I	17	GDS
HVAC - Control	Thermostat – Programmable Thermostat – Wi-Fi Communicating	C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Boiler Setback Control	C&I	15	See note below[36]
	Demand Controlled Ventilation	C&I	15	DEER 2014 EUL ID: HVAC-VSD-DCV
	Heating Management System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Hotel Occupancy Sensors for PTAC and HP Units	C&I	8	DEER[37]
	Steam Traps Repair/Replace	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
Lighting	CFL Lamp	C&I	9,000 hours /annual lighting operating hours	See note below[38]
	CFL Light Fixture	C&I	12	DEER 2014 EUL ID: ILtg-CFLfix-Com
	HID	C&I	70,000 hours /annual lighting operating hours or 15 years (whichever is less)	DEER 2014 EUL ID: ILtg-HPS
	Linear Fluorescent	C&I	70,000 hours /annual lighting operating hours or 15 years, (whichever is less)	DEER 2014[39] EUL ID: ILtg-Lfluor-Elec

[34] 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

[35] 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

[36] Set to 15 years, consistent with Energy Management System (EMS) value in DEER

[37] DEER value for occupancy sensor controls. Hardwired (not battery powered) controls only

[38] Based on reported annual lighting operating hours; default value by space type in the technical manual (pp. 109-110)

[39] Basis Value 70,000 hours, capped at 15 years to reflect C&I redecoration and business type change patterns

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	LED Fixtures (other than refrigerated case)	C&I	50,000 hours /annual lighting operating hours or 20 years (whichever is less)	DLC[40]
			35,000 hours /annual lighting operating hours or 20 years (whichever is less)	Energy Star[41]
			25,000 hours /annual lighting operating hours or 20 years (whichever is less)	Uncertified
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
	LED Screw-In Lamps	C&I	15,000 hours (decorative) or 25,000 hours (all other)/ annual lighting operating hours or 20 years (whichever is less)	Energy Star
Lighting - Control	Interior Lighting Control	C&I	8	DEER 2014 EUL IDs: GlazDayIT-Dayltg, ILtg-OccSens
	Stairwell Dimming Light Fixture/Sensor	C&I	12	GDS[42]
	Plug-Load Occupancy Sensor	C&I	8	DEER[43]
Motors and Drives	Motor Replacement (with HE motor)	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Variable Frequency Drive – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
Refrigeration	Air Cooled Refrigeration Condenser	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Equipment (Condensers, Compressors, and Sub-cooling)	C&I	15	DEER
	EC Fan Motor for Refrigerated Case and Walk-In Cooler	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr

[40] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.2

[41] 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 2.0. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns

[42] GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group

[43] DEER value for lighting occupancy sensors

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Refrigeration	Refrigerated Case Night Cover	C&I	5	DEER 2014 EUL ID: GrocDisp-DispCvrs
	Auto/Fast Close Door Walk-In Coolers/Freezers	C&I	8	DEER
	Strip Curtains and Door Gaskets for Reach-In or Walk-In Coolers/Freezers	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WalkIn-WEvapFMtrCtrl
	Condenser Pressure and Temperature Controls	C&I	15	DEER

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6-14-2	6/19/2014
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GLOSSARY

ABBREVIATIONS, ACRONYMS, AND EQUATION VARIABLES	
$\overline{COP}$	Average coefficient of performance
η	Energy efficiency (0 -100%)
$\overline{\eta}$	Average energy efficiency (0 -100%)
$\overline{\Delta T}$	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/hr) 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/hr) based on Manual J calculation
AHRI	Air Conditioning Heating and Refrigeration Institute
AHU	Air handling unit
AIA	American Institute of Architects
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
BTU	British Thermal Unit
BTUh	British Thermal Units per hour
CAC	Central air conditioner
CADR	Clean Air Delivery Rate (CFM)
Capacity	Cooling output rating, in Btu/hr
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
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_{elec}	Percentage of energy consumed that is derived from electricity
F_{gas}	Percentage of energy consumed that is derived from gas
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 foot
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
H_v	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
$KBTUh_{in}$	Gas input rating (kBTU/h)
$kBTUh_{out}$	Heating output rating (kBTU/h)
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
NAECA	National Appliance Energy Conservation Act of 1987
NBI	New Buildings Institute
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 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
psia	Atmospheric pressure (lbs per square inch)
psig	Gauge pressure (lbs per square inch)
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
TRF	Thermal Regain Factor
TRM	Technical Resource Manual
UA	Overall heat loss coefficient (BTU/hr-°F)
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 0.293 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	kBTUh/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
1,000	Conversion factor, one kW equals 1,000 watts
3,412	Conversion factor, one kWh equals 3,412 BTU
8,760	Hours in one year
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	3/31/2018
6-18-22	6/26/2018

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