Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-20-1	A	3/30/2020	3/30/2020	R/MF Solar Pool Heater	New Measure added	Pg. xx
3-20-3	A	3/30/2020	3/30/2020	C/I High Speed Fan	New Measure added	Pg. xx
3-20-6	A	3/30/2020	3/30/2020	C/I Air Curtain	New Measure added	Pg. xx
3-20-7	A	3/30/2020	3/30/2020	C/I Compressed Air Heat Recovery	New Measure added	Pg. xx
3-20-8	A	3/30/2020	3/30/2020	C/I Central Domestic Hot Water (DHW) Control	New Measure added	Pg. xx
3-20-9	A	3/30/2020	3/30/2020	C/I High-Volume Low Speed (HVLS) Fan	New Measure added	Pg. xx
3-20-13	A	3/30/2020	3/30/2020	C/I Ozone Generator for On-Premises Laundry	New Measure added	Pg. xx
3-20-14	A	3/30/2020	3/30/2020	C/I Floating Head Pressure Control	New Measure added	Pg. xx
3-20-15	R	3/30/2020	3/30/2020	R/MF Fireplace	Removed reference to Iowa TRM; Revised capacity term to output rather than input capacity	Pg. xx
3-20-16	A	3/30/2020	3/30/2020	R/MF Advanced Boiler Control System	New Measure	Pg. xx
3-20-17	R	3/30/2020	3/30/2020	Appendix P	Updated EUL entries for all measures contained in this Record of Revision	Pg. 765
3-20-18	R	3/30/2020	3/30/2020	Glossary	Added entries to align with all measures contained in this Record of Revision	Pg. 778
3-20-19		3/30/2020	3/30/2020	R/MF Energy Management System (EMS)	No revisions applied – measure marked for removal from TRM	Pg. 168

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.

OTHER

SOLAR POOL HEATER

Measure Description

This measure covers the installation of solar pool heating systems with solar thermal collectors. Thermal collectors are composed of long black tubes that absorb sunlight, convert solar energy directly into heat and transfer heat to filtered pool water pumped through the system. Thermal collectors shall be permanently installed on a roof or raised frame.

Solar pool heaters may be installed to partially or fully offset energy consumption of traditional heaters. This measure only applies to solar pool heaters installed in place of or to supplement gas pool heaters for inground swimming pools. Installed thermal collector area must be 50-100% of pool surface area.[1] This methodology assumes that thermal collectors experience minimal shading between the hours of 10AM and 4PM during the summer months. Qualifying thermal collectors must be rated by Solar Rating & Certification Corporation (SRCC) and be OG-100 certified.[2]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

For Single Speed Pool Pumps

$$\Delta kWh = \frac{60 \times days}{1{,}000} \times \frac{GPM}{WEF} \times (hrs_{baseline} - hrs_{ee})$$

For Multi-Speed or Variable Frequency Drive Pool Pumps

$$\Delta kWh = \frac{60 \times days}{1{,}000} \times \left(\frac{F_{HS} \times GPM_{HS} + F_{LS} \times GPM_{LS}}{WEF}\right) \times (hrs_{baseline} - hrs_{ee})$$

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = \frac{CR \times SF \times days \times (1 - F_{derate})}{100{,}000}$$

[1] US DOE "Solar Swimming Pool Heaters".

[2] Solar Rating & Certification Corporation Directory: http://solar-rating.org/programs/og-100-program/. The Solar Rating & Certification Corporation (ICC-SRCC) is an ISO/IEC 17065-accredited third-party certification body with programs for the certification and performance rating of solar heating and cooling products. The OG-100 Solar Thermal Collector Certification Program provides certification for solar thermal collectors to the current ICC 901/SRCC 100 Solar Thermal Collector standard.

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
HS	= High speed operation
LS	= Low speed operation
CR	= Collector Rating (Btu/ft^2-day)
SF	= Square Footage of thermal collectors (ft^2)
days	= Annual days pool heater is used
F_{derate}	= Derating factor
F	= Weighting factor
$hrs_{baseline}$	= Annual pool pump operating hours with gas pool heater
hrs_{ee}	= Annual pool pump operating hours with solar pool heater
WEF	= Weighted Energy factor (kgal/kWh)
GPM	= Gallons per minute
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's
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
CR		From application, as rated by Solar Rating & Certification Corporation. Value shall reflect scenario A (Pool Heating – Warm Climate) and Medium Radiation (1,500 Btu/ft^2-day).[3]
SF		From application.
days		From application. If unknown, use 122 as default, based on 4 months of operation per year.
F_{HS}	0.2	Code of Federal Regulations. [4]
F_{LS}	0.8	Code of Federal Regulations. [5]
F_{derate}	0.06	Derating factor considers approximate shading (3% deration) and operational availability (3% deration).[6]
$hrs_{baseline}$		From application. If unknown, use 11.4[7] as default, assuming two turnovers per day for baseline condition[8].
hrs_{ee}		From application.

[3] Solar Rating & Certification Corporation Directory; scenario selected based on review of NASA Open Data Portal, Prediction of Worldwide Energy Resources (POWER), suggesting that this is the most appropriate selection across NY cities.
[4] 10 CFR Appendix B to Subpart Y of Part 431 – Uniform Test Method for the Measurement of Energy Efficiency of Dedicated-Purpose Pool Pumps
[5] Ibid
[6] NREL "PVWatts Version 5 Manual" Table 6.
[7] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 8/8/2018)
[8] CEE℠ High Efficiency Residential Swimming Pool Initiative, January 2013, pg 33

Variable	Value	Notes
GPM		Look up in Baseline Efficiencies section below, based on pool pump curve (A or C), pool pump type (single speed, multi-speed, or variable frequency drive), and nameplate hp.
WEF		Look up in Baseline Efficiencies section below, based on pool pump curve (A or C), pool pump type (single speed, multi-speed, or variable frequency drive), and nameplate hp.

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is N/A.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is a standard efficiency gas pool heater. The values for baseline WEF and GPM are found in the table below, based on pump type, 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.

Single Speed Pool Pumps

Pump Type and Variable	Nameplate Horsepower					
	3	**2.5**	**2**	**1.5**	**1**	**0.75**
Curve A – WEF	1.6	1.9	1.9	2.1	2.4	2.6
Curve A – GPM	73	68	65	64	60	53
Curve C – WEF	2.0	2.2	2.3	2.3	2.5	3.3
Curve C – GPM	102	93	89	78	76	65

Multi-Speed Pool Pumps

Pump Type and Variable	Nameplate Horsepower at High Speed					
	3	**2.5**	**2**	**1.5**	**1**	**0.75**
Curve A – WEF	2.9	3.3	3.4	3.8	3.9	4.3
Curve A – GPM_{HS}	74.0	66.0	66.4	61.0	56.0	56.0
Curve A – GPM_{LS}	37.0	34.0	33.3	31.9	31.0	29.0
Curve C – WEF	3.6	4.0	4.1	4.6	4.9	5.4
Curve C – GPM_{HS}	102.0	90.0	89.7	78.0	70.0	73.0
Curve C – GPM_{LS}	51.0	45.7	44.8	41.8	40.3	37.0

Variable Frequency Drive Pumps

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

Pool Curve Type	WEF
Curve A	$WEF = 20.554\ e^{-0.034\ \times(0.2\times GPM_{HS}+0.8\times GPM_{LS})}$
Curve C	$WEF = 27.188\ e^{-0.026\ \times(0.2\times GPM_{HS}+0.8\times GPM_{LS})}$

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is a thermal collector installed to offset or replace the consumption of a traditional gas pool heater for an inground swimming pool. Qualifying thermal collectors must be rated by Solar Rating & Certification Corporation's OG-100 program.

Operating Hours

The annual operating days shall be taken from application. If actual operating days are unknown, 122 days may be used as a default, assuming 4 months of operation per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Addition of a thermal collector will require additional run time of pool pump. This additional electric consumption is considered in the ΔkWh equation above.

References

1. Department of Energy, Solar Swimming Pool Heaters
   Available from: https://www.energy.gov/energysaver/solar-swimming-pool-heaters
2. Solar Rating & Certification Corporation directory
   Available from: http://solar-rating.org/directories/certified-companies/
3. National Renewable Energy Laboratory, PVWatts Version 5 Manual, September 2014
   Available from: https://www.nrel.gov/docs/fy14osti/62641.pdf
4. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
5. NASA's Open Data Portal, Prediction of Worldwide Energy Resources (POWER) Available from: https://data.nasa.gov/Earth-Science/Prediction-Of-Worldwide-Energy-Resources-POWER-/wn3p-qsan

6. 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
7. CEE℠ High Efficiency Residential Swimming Pool Initiative, Consortium for Energy Efficiency, January 2013
Available from:
https://library.cee1.org/system/files/library/9986/CEE_Res_SwimmingPoolInitiative_01Jan2013_Corrected.pdf
8. 10 CFR Appendix B to Subpart Y of Part 431 – Uniform Test Method for the Measurement of Energy Efficiency of Dedicated-Purpose Pool Pumps
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=1e172a51fbd7c0fa1753866066133e14&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1466.b

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Agricultural Equipment

High Speed Fan

Measure Description

This measure is applicable to the installation of high speed, high efficiency fans installed in agricultural applications. For the purposes of this measure, a high speed fan shall consist of the blade and motor assembly. Ventilation, exhaust and circulating high speed fans improve animal comfort, control moisture and maintain indoor air quality for livestock and other agricultural applications. Variable frequency drives (VFD) may be installed along with high speed fans to increase energy savings and the associated savings are quantified by this methodology. If VFD savings are claimed via this measure, additional savings may not be claimed for VFDs utilizing a separate methodology. Qualifying fans must be rated by an Air Movement and Control Association (AMCA) accredited laboratory such as Bioenvironmental and Structural Systems (BESS) Laboratories.[9]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings for Ventilation and Exhaust Fans

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{\left[\left(\frac{CFM_{baseline}}{\left(\frac{CFM}{Watt}\right)_{baseline}}\right) - \left(\frac{CFM_{ee}}{\left(\frac{CFM}{Watt}\right)_{ee}} \times F_{VFD,ee}\right)\right]}{1,000} \times hrs$$

Summer Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of fans installed under the program
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
CFM = Air flow, measured in cubic feet per minute
CFM/watt = Ventilating efficiency ratio, rated at 0.01'' static pressure in cubic feet per minute

[9] BESS Laboratories is a research, product testing, and educational laboratory at the University of Illinois.

per watt
F_{VFD} = Factor to account for reduced consumption resultant from VFD control
hrs = Annual hours of operation
CF = Coincidence Factor
1,000 = Conversion factor, one kW equals 1,000 Watts

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings for Circulation Fans

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\left(\frac{lbf_{baseline}}{\left(\frac{lbf}{kW}\right)_{baseline}} \right) - \left(\frac{lbf_{ee}}{\left(\frac{lbf}{kW}\right)_{ee}} \times F_{VFD,ee} \right) \right] \times hrs$$

Summer Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:
ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of fans installed under the program
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
lbf = Thrust, in pounds-force
lbf/kW = Thrust efficiency ratio, in pounds-force per kilowatt
F_{VFD} = Factor to account for reduced consumption resultant from VFD control
hrs = Annual hours of operation
CF = Coincidence Factor
1,000 = Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
$CFM_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use CFM_{ee} as the default value.
CFM_{ee}		From application.

Variable	Value	Notes
$(CFM/watt)_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If not tested by BESS Labs, look up from Baseline Efficiencies section below based on fan diameter.
$(CFM/watt)_{ee}$		From application, look up from BESS Labs database based on manufacturer and model number or as rated by other third-party accredited laboratory
$lbf_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use lbf_{ee} as the default value.
lbf_{ee}		From application.
$(lbf/kW)_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If not tested by BESS Labs, look up from Baseline Efficiencies section below based on fan diameter.
$(lbf/kW)_{ee}$		From application, look up from BESS Labs database based on manufacturer and model number or as rated by other third-party accredited laboratory
$F_{VFD,ee}$	No VFD: 1.00 VFD (Greenhouse): 0.64 VFD (Poultry/Livestock): 0.75	Adjustment to efficient condition consumption to account for VFD control, based on presence of VFDs and fan application.[10]
hrs		From application. If unavailable, lookup in Operating Hours section below.
CF	1.0	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 1.0.[11]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is a standard efficiency exhaust, ventilation or circulating fan. Baseline fan airflow (CFM) for exhaust and ventilation fans or thrust (lbf) for circulating fans

[10] Teitel, M. & Levi, Asher & Zhao, Yun & Barak, Moti & Bar-lev, Eli & Shmuel, David. (2008). Energy saving in agricultural buildings through fan motor control by variable frequency drives. Energy and Buildings. 40. 953-960. 10.1016/j.enbuild.2007.07.010.

[11] It is assumed that fans will always be running during the peak hour.

and fan efficiency shall come from application. If unavailable, look up from the table below based on fan type and diameter.[12]

Fan Diameter	Ventilation and Exhaust Fans (CFM/W)	Circulating Fans (lbf/kW)
24" – 35"	9.4	10.5
36" - 47"	12.2	12.9
48" - 52"	15.1	19.8
53"+	16.7	20.8

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is a high speed exhaust, ventilation or circulating fan that meets or exceeds the minimum efficiency requirements from the table below, based on fan type and diameter.[13]

Fan Diameter	Ventilation and Exhaust Fans (CFM/W)	Circulating Fans (lbf/kW)
24" – 35"	14.0	15.0
36" - 47"	17.0	20.0
48" - 52"	19.9	24.2
53"+	22.0	24.6

Operating Hours

Fan operating hours shall come from application. If operating hours are unknown, the prescribed hours shall come from the lookup table below based on location. Default hours are developed from NOAA hourly normals by summing annual hours dry bulb temperature is above 50ºF.[14]

City	Circulation Fan Hours	Exhaust/Ventilation Fan Hours[15]
Albany	4,238	7,446
Binghamton	3,969	7,446
Buffalo	4,189	7,446
Massena*	4,156	7,446
NYC	5,162	7,446
Poughkeepsie**	4,722	7,446
Syracuse	4,179	7,446

*Massena hourly normals are approximated from Rochester airport data due to limited available data
** Poughkeepsie hourly normals are approximated from Long Island ISLIP airport data due to limited available data

[12] Default baseline efficiency was determined by calculating the 10th percentile of the efficiencies of all fans in the active BESS Labs database for the respective fan diameter ranges. Many low efficiency fans are often not tested by BESS Labs, therefore the average tested fan is more efficient than the average market available fan. Ventilation and exhaust fan CFM and circulating fan lbf represent the averages of each diameter range, regardless of fan efficiency. The database includes single and three phase fans at four voltages.
[13] Minimum qualifying fan efficiency is equivalent to the 75th percentile of all BESS Labs tested in the respective fan diameters. The database includes single and three phase fans at four voltages.
[14] NOAA National Centers for Environmental information – NCEI 2010 Hourly Normals
[15] Exhaust/Ventilation fans are assumed to operate 85% of total annual hours (8,760 x 0.85 = 7,446).

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Teitel, M. & Levi, Asher & Zhao, Yun & Barak, Moti & Bar-lev, Eli & Shmuel, David. (2008). Energy saving in agricultural buildings through fan motor control by variable frequency drives. Energy and Buildings. 40. 953-960. 10.1016/j.enbuild.2007.07.010. Available from: https://www.researchgate.net/publication/223846494_Energy_saving_in_agricultural_buildings_through_fan_motor_control_by_variable_frequency_drives
2. Agricultural Ventilation Fans, Bioenvironmental and Structural Systems Laboratory, University of Illinois, Department of Agricultural and Biological Engineering, Accessed September 26, 2019
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3. Circulating Fans, Bioenvironmental and Structural Systems Laboratory, University of Illinois, Department of Agricultural and Biological Engineering, Accessed September 26, 2019
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4. NOAA National Centers for Environmental Information
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BUILDING SHELL

AIR CURTAIN

Measure Description

This measure is applicable to the installation of air curtains, which act as air barriers between environments. Also known as air doors, air curtains act as a controlled barrier for environmental and thermal separation between conditioned and unconditioned air when a building's doors are opened. They reduce cross mitigation of warm, lighter air flowing through the upper part of the opening and cold, heavier air flowing through the lower part of the opening while allowing an uninterrupted flow of traffic and unobstructed vision through the opening.

Qualifying air curtains must cover the entire door opening and operate only during the cooling and heating seasons. This measure is only applicable to entryways with overhead doors between indoor conditioned and outdoor unconditioned spaces.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating}\right)$$

$$\Delta kWh_{cooling} = \left\{\left[\frac{\Delta(kBTU/h)_{cooling}}{Eff_{ElecCool}}\right] - (hp_{curtain} \times 0.746)\right\} \times hrs \times days_{cooling}$$

$$\Delta kWh_{heating} = \left\{\left[\frac{\Delta(kBTU/h)_{heating}}{Eff_{ElecHeat}}\right] \times F_{ElecHeat} - (hp_{curtain} \times 0.746)\right\} \times hrs \times days_{heating}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{\Delta kWh_{cooling}}{days_{cooling} \times 24} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left[\frac{\Delta(kBTU/h)_{heating}}{Eff_{GasHeat} \times 100}\right] \times F_{GasHeat} \times hrs \times days_{heating}$$

where:

$$\Delta(kBTU/h)_{cooling} = \frac{4.5 \times Q_{A,cooling} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000} \times Eff_{curtain}$$

$$Q_{A,cooling} = \sqrt{Q_{wind,cooling}{}^2 + Q_{thermal,cooling}{}^2}$$

$$Q_{wind,cooling} = MPH_{cooling} \times ht \times l \times F_{opening} \times 88$$

$$Q_{thermal,cooling} = 60 \times ht \times l \times F_{discharge} \times \sqrt{32.2 \times ht \times \frac{(T_{outdoor,cooling} - T_{indoor,cooling})}{(T_{outdoor,cooling} + 459.67)}}$$

$$\Delta(kBTU/h)_{heating} = \frac{1.08 \times Q_{A,heating} \times (T_{indoor,heating} - T_{outdoor,heating})}{1{,}000} \times Eff_{curtain}$$

$$Q_{A,heating} = \sqrt{Q_{wind,heating}{}^2 + Q_{thermal,heating}{}^2}$$

$$Q_{wind,heating} = MPH_{heating} \times ht \times l \times F_{opening} \times 88$$

$$Q_{thermal,heating} = 60 \times ht \times l \times F_{discharge} \times \sqrt{32.2 \times ht \times \frac{(T_{indoor,heating} - T_{outdoor,heating})}{(T_{indoor,heating} + 459.67)}}$$

where:

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
heating = Property of heating season
cooling = Property of cooling season
Δ(kBTU/h) = Change in rate of heat transfer through doorway
$Eff_{ElecCool}$ = Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (≥65,000 BTU/h)
$Eff_{ElecHeat}$ = Seasonal average energy efficiency of electric heating equipment. Heating Seasonal Performance Factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heating) during the heating season / total electric energy heat pump consumed (in watt-hour); if equipment efficiency is reported in COP, convert to HSPF using the equivalency HSPF = COP x 3.412
$Eff_{GasHeat}$ = Gas heating system efficiency
$F_{ElecHeat}$ = Electric heating factor, used to include electric heating system impacts as applicable
$F_{GasHeat}$ = Gas heating factor, used to include gas heating system impacts as applicable
$hp_{curtain}$ = Horsepower of air curtain motor

hrs = Daily run hours of air curtains
days = Days of operation of air curtains
CF = Coincident factor
Q_A = Total air flow entering doorway, in Cubic Feet per Minute
H_{indoor} = Average indoor enthalpy
$H_{outdoor}$ = Average outdoor enthalpy
T_{indoor} = Average indoor set temperature
$T_{outdoor}$ = Average outdoor temperature
$Eff_{curtain}$ = Effectiveness of air curtain
Q_{wind} = Air flow entering doorway due to wind
$Q_{thermal}$ = Air flow entering doorway due to thermal factors
MPH = Wind speed, in miles per hour
ht = height of doorway, in feet
l = length of doorway, in feet
$F_{opening}$ = Effectiveness of opening factor
$F_{discharge}$ = Discharge coefficient for opening
0.746 = Conversion factor (kW/hp), 746 watts equals one electric horsepower
24 = Hours in one day
100 = Conversion factor, one therm equals 100 kBTU
4.5 = Density of inlet air at 70ºF x 60 min/hr, in lb-min/ft^3-hr
1.08 = Specific heat of air x density of inlet air at 70ºF x 60 min/hr, in BTU/h-ºF-CFM
1,000 = Conversion factor from BTU to kBTU
88 = Conversion factor, one mile per hour equals 88 feet per minute
60 = Conversion factor, one minute equals 60 seconds
32.2 = Gravitational Constant, in ft/s^2
459.67 = Conversion factor, Fahrenheit to Rankine

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta(kBTU/h)_{cooling}$		Calculate per prescribed algorithms above. Using suggested default values in this methodology, there is a fixed linear relationship between $\Delta(kBTU/h)_{cooling}$ and the area of the entryway served by the air curtain. As such, a simplified approach for establishing default $\Delta(kBTU/h)_{cooling}$ values based on location and entryway area (A = ht x l) in ft^2 are provided in the Default Values table below.
$\Delta(kBTU/h)_{heating}$		Calculate per prescribed algorithms above. Using suggested default values in this methodology, there is a fixed linear relationship between $\Delta(kBTU/h)_{heating}$ and the area of the entryway served by the air curtain. As such, a simplified approach for establishing default $\Delta(kBTU/h)_{heating}$ values based on location and entryway area (A = ht x l) in ft^2 are provided in the Default Values table below.
$Eff_{ElecCool}$		From application. SEER or IEER shall be used, based on nameplate rating metric of existing equipment.

Variable	Value	Notes
$Eff_{ElecHeat}$		From application. HSPF shall be used, based on nameplate rating metric of existing equipment. If equipment is rated in COP, convert to HSPF using the equivalency HPSF = COP x 3.412.
$Eff_{GasHeat}$		From application. E_c, E_t, or AFUE shall be used, based on nameplate rating metric of existing equipment.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{GasHeat}$		Use a value of 1.0 if the building is gas heated. Otherwise use 0.0.
$hp_{curtain}$		From application
hrs		From application
$days_{cooling}$		From application, or lookup based on location and season in table below.
$days_{heating}$		From application, or lookup based on location and season in table below.
CF	0.8	
$H_{indoor,cooling}$	34.6	Based on 85°F and 50% RH
$H_{outdoor,cooling}$		Lookup from Climate Data table below based on location[16]
$T_{indoor,cooling}$		From application or use 85°F as a default.[17]
$T_{outdoor,cooling}$		Lookup from Climate Data table below based on location[18]
$T_{indoor,heating}$		From application or use 60°F as a default.[19]
$T_{outdoor,heating}$		Lookup from Climate Data table below based on location[20]
$Eff_{curtain}$	0.7	Curtain effectiveness, based on midpoint of expected range (0.6 – 0.8)[21]
$MPH_{cooling}$		Lookup from Climate Data table below based on location[22]
$MPH_{heating}$		Lookup from Climate Data table below based on location[23]
ht		From application
l		From application
$F_{opening}$	0.3	Assumes diagonal wind[24]

[16] NCEI 1981-2010 Annual/Seasonal Climate Normals
[17] IECC 2018; Table C403.4.1.4 Heated or Cooled Vestibules (Mandatory)
[18] NCEI 1981-2010 Annual/Seasonal Climate Normals
[19] IECC 2018; Table C403.4.1.4 Heated or Cooled Vestibules (Mandatory)
[20] NCEI 1981-2010 Annual/Seasonal Climate Normals
[21] 2019 ASHARE Handbook – HVAC Applications, Chapter 58, page 58.34
[22] Ibid
[23] Ibid
[24] 2017 ASHRAE Handbook – Fundamentals, Chapter 16, page 16.14

Variable	Value	Notes
$F_{discharge}$	0.4	The discharge coefficient accounts for all viscous effects such as surface drag and interfacial mixing through the door, dependent on number of entry points into the conditioned space.[25] A single entrance is assumed for simplicity. Effects of indoor and outdoor temperature differential are expected to have negligible impact on this factor and are therefore ignored.

Default Values[26]

City	$\Delta(kBTU/h)_{cooling}$	$\Delta(kBTU/h)_{heating}$
Albany	4.12A - 0.48	2.57A - 1.06
Binghamton	3.68A - 0.16	2.82A - 0.95
Buffalo	4.92A - 0.14	3.15A - 0.76
Massena	3.72A - 0.36	2.41A - 0.95
NYC	7.00A - 0.56	2.43A - 0.35
Poughkeepsie	3.15A - 0.66	1.25A - 0.76
Syracuse	4.16A - 0.42	2.68A - 0.93

Climate Data[27,28,29,30]

City	$T_{outdoor, cooling}$ (ºF)	$T_{outdoor, heating}$ (ºF)	$H_{outdoor,cooling}$ (BTU/lb)	$MPH_{cooling}$ (mph)	$MPH_{heating}$ (mph)
Albany	87.3	45.5	36.2	6.43	8.46
Binghamton	86.1	45.5	35.3	7.23	9.41
Buffalo	86.0	46.0	35.3	8.67	10.99
Massena	86.8	46.3	35.9	6.23	8.41
NYC	88.7	50.1	37.3	9.70	12.09
Poughkeepsie	86.9	49.7	35.9	4.30	5.70
Syracuse	87.2	45.8	36.1	6.77	9.14

[25] 2017 ASHRAE Handbook – Fundamentals, Chapter 16, page 16.14. equation 39
[26] "A" represents the area of the doorway in ft^2 (A = ht x l).
[27] NCEI 1981-2010 Annual/Seasonal Climate Normals
[28] 2017 ASHRAE Handbook – Fundamentals, Chapter 14, Climate Data Tables
[29] The cooling season is defined as the date range over which the outdoor air temperature is above 85°F for at least one hour in a day. The cooling season is defined as the date range over which the outdoor air temperature is below 60°F for at least one hour in a day. Temperature values are based on the 90th percentile hourly temperature during the cooling and heating seasons.
[30] Enthalpy values are based on psychrometric analysis of air at average dry bulb and wet bulb temperatures across the cooling season when the outdoor dry bulb temperature is above the assumed balance point of 65F.
MPH values reflect the average monthly values throughout the respective season (cooling/heating) identified by the ASHRAE Handbook.

Days of Operation[31]

City	Heating Season Days	Cooling Season Days
Albany	227	72
Binghamton	227	7
Buffalo	203	45
Massena	209	68
NYC	180	98
Poughkeepsie	205	58
Syracuse	217	70

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.8.[32]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is an entryway with overhead doors and no air curtains installed.

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is an air curtain over an entryway with overhead doors between conditioned and unconditioned spaces. Qualifying air curtains must cover the entire door opening. Air curtains shall operate only during the cooling and heating seasons.

Operating Hours

Air curtain operating hours shall be based on application. Default values for number of operating days in cooling and heating seasons are provided in the Summary of Variables and Data Sources table above.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

In addition to cooling and heating savings, installation of an air curtain results in increased electric load due to added fan power.

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[31] Derived from NCEI 1981-2010 Annual/Seasonal Climate Normals. Heating Season Days reflect the number of days in the year on which the 90th percentile hourly temperature falls below 60°F for at least one hour. Similarly, Cooling Season Days reflect the number of days in the year on which the 90th percentile hourly temperature falls above 85°F for at least one hour

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

References

1. NOAA National Center for Environmental Information – NCEI 1981 – 2010 Annual/Seasonal Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
2. IECC 2018; Table C403.4.1.4 Heated or Cooled Vestibules (Mandatory)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
3. 2019 ASHRAE Handbook – HVAC Applications, Chapter 58: Room Air Distribution
4. 2017 ASHRAE Handbook – Fundamentals, Chapter 16: Ventilation and Infiltration
5. 2017 ASHRAE Handbook – Fundamentals, Chapter 14: Climate Design Information

Record of Revision

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3-20-6	3/30/2020

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Compressed Air

Compressed Air Heat Recovery

Measure Description

This measure covers the installation of a compressed air heat recovery system on an air-cooled compressor system. The mechanical work of an air compressor yields large amounts of waste heat. This waste heat can be used for either space heat, domestic hot water, or process heating applications depending on the temperature of the waste heat stream. A heat recovery system is an equipment add-on retrofit to either an air-cooled or water-cooled air compressor system. With air-cooled compressor systems, typical retrofits require ductwork and fans for heat recovery. For water-cooled air compressor systems, either a water-to-air or water-to-water heat exchanger is necessary. Water-cooled air compressor systems are not addressed by this measure.

This measure only considers waste heat recovery for space heating. This measure is applicable in retrofit applications only and is not applicable to backup or redundant units.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{hp_{comp} \times LF \times RE \times hrs \times 0.746}{COP_{heating}} \times F_{ElecHeat}\right) - \left(\frac{hp_{fan} \times 0.746 \times hrs}{Eff_{fan}}\right)$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = \frac{hp_{comp} \times LF \times RE \times hrs \times 0.746}{Eff_{heating}} \times F_{GasHeat} \times \frac{3{,}412}{100{,}000}$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
hp_{comp} = Compressor motor horsepower
hp_{fan} = Distribution fan motor horsepower
LF = Average load factor of the compressor motor
RE = Recovery efficiency based on brake horsepower
hrs = Annual heating hours coincident with compressor operation
$COP_{heating}$ = Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$Eff_{heating}$ = Efficiency of gas heating system
$F_{ElecHeat}$ = Electric heating factor; used to account for the presence or absence of an

electric heating system
$F_{GasHeat}$ = Gas heating factor; used to account for the presence or absence of a gas heating system
Eff_{fan} = Motor efficiency of fan
0.746 = Conversion factor (kW/hp), 746 watts equals one horsepower
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
hp_{comp}		From application.
hp_{fan}		From application. If unknown assume 1.0 hp or if no fan is in use, use 0 hp. If a fan is already used to exhaust the heat outside, the value will be the difference in hp between the two fans or 0 if the same.
LF		From application. If unknown use 0.92.[33]
RE		From application. If unknown use 0.8.[34]
hrs		From application. If unknown, lookup in Operating hours section below based on location and facility type.[35]
$COP_{heating}$		From application. If unknown use 3.2 for heat pumps. For electric resistance heating, use a value of 1.0.
$Eff_{heating}$		From application. If unknown use a value of 0.8.
$F_{ElecHeat}$		If a central electric heating system is present, set equal to 1. Otherwise, set equal to 0.
$F_{GasHeat}$		If a central gas heating system is present, set equal to 1. Otherwise, set equal to 0.
Eff_{fan}		From application. Value should be based on the rated NEMA Premium efficiency of the motor installed. If unknown assume 0.86 for a 1 horsepower fan motor.[36] Calculation assumes fan is fully loaded when on.

Coincidence Factor (CF)

Compressed air heat recovery savings described by this measure offset facility space heating load only. As a result, no summer peak demand savings shall be claimed and the prescribed value for the coincidence factor is N/A.

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[33] Cascade Energy. "Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors." Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012. Assumes 30 hp air compressor.
[34] "Compressed Air Challenge™, Heat Recovery with Compressed Air Systems." Compressed Air Systems Fact Sheet #10.
[35] Cadmus. Focus on Energy Evaluated Deemed Savings Changes. August 31, 2017.
[36] U.S. Department of Energy. "Premium Efficiency Motor Selection and Application Guide". Table 2-1. EISA Mandatory Minimum Full-Load Efficiency Standards, % (for motors rated 600 V or less). February 2014.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is an air-cooled air compressor without a heat recovery system in a building with electric or natural gas space heating.

Compliance Efficiency from which Incentives are Calculated

The energy efficient condition is an air-cooled air compressor with a heat recovery system in a building with electric or natural gas space heating.

Operating Hours

Operating hours to be used in this measure reflect hours when operation of air compressor is coincident with heating hours. Hours shall come from application. If unknown, look up in table below based on facility type and average run hours.

Facility Type[37]	Albany	Binghamton	Buffalo	Massena*	NYC	Poughkeepsie**	Syracuse
Single Shift	1,501	1,552	1,541	1,529	1,444	1,495	1,513
Two Shift	2,856	2,940	2,925	2,903	2,760	2,874	2,880
Three Shift	4,080	4,164	4,149	4,127	3,984	4,098	4,104
Continuous	5,676	5,785	5,769	5,743	5,552	5,704	5,711

*Massena hourly normals are approximated from Rochester airport data due to limited available data
** Poughkeepsie hourly normals are approximated from Long Island ISLIP airport data due to limited available data

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Compressed Air Heat Recovery may lead to increased electric consumption resulting from the addition of fan power for heat recovery. These impacts are addressed in the prescribed methodology.

References

1. Cascade Energy. "Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors." Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012.
   Available from: https://rtf.nwcouncil.org/meeting/rtf-meeting-november-14-2012

[37] Compressor Run Hours is determined by breaking the hours in Single Shift 7am-3pm M-F, Two Shift 7am-11pm M-F, Three Shift 24 hours M-F and Continuous 24/7.

2. "Compressed Air Challenge™, Heat Recovery with Compressed Air Systems." Compressed Air Systems Fact Sheet #10.
Available from:
https://www.compressedairchallenge.org/data/sites/1/media/library/factsheets/factsheet10.pdf
3. Cadmus. Focus on Energy Evaluated Deemed Savings Changes. August 31, 2017.
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4. U.S. Department of Energy. "Premium Efficiency Motor Selection and Application Guide". Table 2-1. EISA Mandatory Minimum Full-Load Efficiency Standards, % (for motors rated 600 V or less). February 2014.
Available from:
https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf
5. U.S. Department of Energy. "Evaluation of the Compressed Air Challenge® Training Program". March 2004.
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3-20-7	3/30/2020

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DOMESTIC HOT WATER (DHW) - CONTROL

CENTRAL DOMESTIC HOT WATER (DHW) CONTROL

Measure Description

This measure is applicable to the installation of temperature modulation and demand controls on central domestic hot water (DHW) systems with recirculation. Temperature modulation controls reduce circulator pump energy and recirculation heat losses by modulating DHW system supply temperatures according to a set schedule, activating recirculation when supply water drops below the set point. Demand controls limit energy consumption by activating recirculation loops based on demand. DHW demand controls must monitor calls for hot water and return water temperature, activating recirculation when demand is detected or return water has dropped below a prescribed temperature. Temperature modulation and demand controls achieve savings without significant interruptions to instantaneous hot water availability.

This measure is not applicable to new construction or gut rehab installations.[38] This measure is not applicable in facilities where twenty-four-hour recirculation and delivered hot water temperature is required by code. DHW demand control systems shall be installed by a qualified contractor complying with all relevant construction and safety codes and standards.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{pump} + \Delta kWh_{HW}$$

$$\Delta kWh_{pump} = \frac{hp \times 0.746}{Eff_{pump}} \times LF \times hrs_{recirc,baseline} \times ESF_{pump}$$

$$\Delta kWh_{HW} = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \frac{1}{E_{t,elec}} \times \frac{hrs_{recirc,baseline}}{8{,}760} \times ESF_{HW}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{hrs_{recirc,baseline}} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \frac{1}{E_{t,gas}} \times \frac{hrs_{recirc,baseline}}{8{,}760} \times ESF_{HW}$$

where:

ΔkWh = Annual electricity energy savings

[38] ECCCNYS C404.7 and IPC 607.2

ΔkW = Peak coincident demand electric savings
$\Delta therms$ = Annual gas energy savings
hp = Total recirculation system pump horsepower
Eff = Efficiency
$_{pump}$ = Property of circulator pump
LF = Load Factor
$hrs_{recirc,baseline}$ = Annual hours of operation of recirculation system in the baseline condition
ESF = Energy savings factor
GPD = Gallons per day
ΔT_{main} = Average temperature difference between water heater set point temperature and the supply water temperature in water main (ºF)
E_t = Thermal efficiency
$_{elec}$ = Property of electrical central DHW system
$_{gas}$ = Property of gas central DHW system
$_{HW}$ = Hot water
CF = Coincidence Factor
0.746 = Conversion factor (kW/hp), 746 watts equals one electric horsepower
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
8,760 = Hours in one year
365 = Days in one year
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application.
Eff_{pump}	PSC Pump: 0.60 ECM Pump: 0.80	PSC pump efficiency[39] ECM pump efficiency[40] If unknown, use a value of 0.80.
LF	0.9	Assumed value to reflect that motors do not typically run at 100% of rated power.
$hrs_{recirc,baseline}$		From application.
GPD		From application, or lookup/calculate based on building type, square footage and occupancy from 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 (ºF)

[39] US DOE, Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment, Table 2.1 Summary of Single-Phase AC Induction Motor Characteristics - Efficiency of the baseline condition is taken as the average full load efficiency rating range for a PSC motor.
[40] ACHR News, Comparing Motor Technologies, December 2009

Variable	Value	Notes
T_{set}		Water heater set point temperature (ºF), per application of use 140ºF as default.[41]
T_{main}		Supply water temperature in water main (ºF). Lookup in Cold Water Inlet Temperature table below based on nearest city.
$E_{t,elec}$	0.98	Thermal efficiency of electric water heater.[42]
$E_{t,gas}$	0.80	Thermal efficiency of gas water heaters.[43]
ESF_{pump}	0.87	Minnesota Department of Commerce[44]
ESF_{HW}		Lookup based on control type in the Energy Savings Factor section below.
CF	0.8	

<u>Gallons per Day (GPD)</u>

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[45]: 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[46]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation[47]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC[48]: 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

[41] Per OSHA recommendations for prevention of Legionella bacterial growth

[42] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

[43] Per 10 CFR 431.110(a)

[44] Center for Energy and Environment, Evaluation of New DHW System Controls in Hospitality and Commercial Buildings, Prepared for Minnesota Department of Commerce, Division of Energy Resources, June 30, 2018, pg 12

[45] 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

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

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

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

Building Type	GPD	Rate	Notes/Assumptions	Source
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.[49] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[50] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Energy Savings Factor

The hot water energy savings factor (ESF_{HW}) is dependent on the installed control type.

Control Type	ESF_{HW}	Notes
Demand Control	0.07	NREL[51]
Temperature Modulation	0.02	NREL[52]
Demand Control and Temperature Modulation	0.15	NREL[53]

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8. [54]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is a central DHW recirculation system running in continuous operation.

Compliance Efficiency from which Incentives are Calculated

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

[50] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

[51] NREL, Control Strategies to Reduce the Energy Consumption of Central Domestic Hot Water Systems, June 2016

[52] Ibid

[53] Ibid

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

The compliance condition is a central DHW recirculation system with a control system that regulates circulator pump operation based on demand, temperature or both. Recirculation system controls must be installed by a qualified contractor complying with all relevant construction and safety codes and standards.

Operating Hours

Baseline recirculation hours drive savings and shall come from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ECCCNYS 2016, C404.7 Demand recirculation controls
   Available from: https://codes.iccsafe.org/content/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. IPC 2015, 607.2.1.2 Demand recirculation controls for distribution system
   Available from: https://codes.iccsafe.org/content/IFGC2015NY/chapter-6-water-supply-and-distribution
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7. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from:
   https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html

8. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters
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11. National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011
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12. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016
Available from: https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf
13. 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
14. Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
Available from: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=05D73BA6EF5ECCF71969D083FB317991?doi=10.1.1.515.6885&rep=rep1&type=pdf
15. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
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Heating, Ventilation and Air Conditioning (HVAC)

High-Volume Low Speed (HVLS) Fan

Measure Description

This measure is applicable to the installation of high-volume low speed (HVLS) fans in C&I applications. HVLS fans are ceiling mounted fans that move large amounts of air more efficiently and with lower noise levels. For the purposes of this measure, a fan shall consist of the blade and motor assembly . Installed in exhaust, ventilation, or circulation applications, HVLS fans replace multiple smaller fans.

Variable frequency drives (VFD) may be installed along with high speed fans to increase energy savings and the associated savings are quantified by this methodology. If VFD savings are claimed via this measure, additional savings may not be claimed for VFDs utilizing a separate methodology.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left[\left(units_{baseline} \times \frac{CFM_{baseline}}{(CFM/Watt)_{baseline}}\right) - \left(units_{ee} \times \frac{CFM_{ee}}{(CFM/Watt)_{ee}} \times F_{VFD,ee}\right)\right] \times \frac{hrs}{1{,}000}$$

Summer Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
units	= Number of fans installed or removed under the program
CFM	= Air flow, measured in cubic feet per minute
CFM/Watt	= Fan efficiency ratio, rated at 0.01" static pressure in cubic feet per minute per watt
F_{VFD}	= Factor to account for reduced consumption resultant from VFD control
hrs	= Annual hours of operation

CF = Coincidence Factor
1,000 = Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
$units_{baseline}$		From application. If unknown, assume 5.[55]
$units_{ee}$		From application.
$CFM_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use CFM_{ee} as the default value.
CFM_{ee}		From application.
$(CFM/watt)_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use 15.1.[56]
$(CFM/watt)_{ee}$		From application.
$F_{VFD,ee}$	No VFD: 1.00 VFD (Greenhouse): 0.64 VFD (Other): 0.75	Adjustment to efficient condition consumption to account for VFD control, based on presence of VFDs and fan application.[57]
hrs		From application. If unknown, look up from table below based on location for agricultural applications. For other C&I applications, assume fan operating hours align with the operating hours prescribed in the C&I Interior and Exterior Lighting measure found in this document, based on facility type.
CF	0.8	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.8.[58]

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[55] Kammel, David & Raabe, & Kappelman, J.. (2003). Design of high volume low speed fan supplemental cooling system in dairy freestall barns. Proceedings of the Fifth International Dairy Housing Conference. 10.13031/2013.11628.

[56] Default baseline efficiency was determined by calculating the 10th percentile of the efficiencies of all fans in the active BESS Labs database for 48" ventilation fan. Many low efficiency fans are often not tested by BESS Labs, therefore the average tested fan is more efficient than the average market available fan. The database includes single and three phase fans at four voltages.

[57] Teitel, M. & Levi, Asher & Zhao, Yun & Barak, Moti & Bar-lev, Eli & Shmuel, David. (2008). Energy saving in agricultural buildings through fan motor control by variable frequency drives. Energy and Buildings. 40. 953-960. 10.1016/j.enbuild.2007.07.010.

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is multiple smaller fans. CFM and CFM/Watt shall come from application. If unknown, or for new installations, assume 15.1 CFM/Watt. [59]

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is a HVLS fan, at least 16 feet in diameter.

Operating Hours

Operating hours shall come from application. If operating hours are unknown, the prescribed hours shall come from the lookup table below based on location for agricultural applications. Default hours are developed from NOAA hourly normals by summing annual hours dry bulb temperature is above 50ºF.[60]

City	Hours
Albany	4,238
Binghamton	3,969
Buffalo	4,189
Massena*	4,156
NYC	5,162
Poughkeepsie**	4,722
Syracuse	4,179

*Massena hourly normals are approximated from Rochester airport data due to limited available data
** Poughkeepsie hourly normals are approximated from Long Island ISLIP airport data due to limited available data

For other C&I applications, assume fan operating hours align with the operating hours prescribed in the C&I Interior and Exterior Lighting measure found in this document, based on facility type.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

HVLS are used for air destratification. The destratification of air during heating and cooling seasons in a conditioned space can decrease heating and cooling load required to achieve occupant comfort and leads to additional energy savings. Because this measure considers HVLS fans as a replacement for multiple conventional, smaller fans, impacts to heating and cooling load are not quantified.

[59] Default baseline efficiency was determined by calculating the 10th percentile of the efficiencies of all fans in the active BESS Labs database for 48" ventilation fan. Many low efficiency fans are often not tested by BESS Labs, therefore the average tested fan is more efficient than the average market available fan. The database includes single and three phase fans at four voltages.
[60] NOAA National Centers for Environmental information – NCEI 2010 Hourly Normals

Ancillary Electric Savings Impacts

HVLS are used for air destratification. The destratification of air during heating and cooling seasons in a conditioned space can decrease heating and cooling load required to achieve occupant comfort and leads to additional energy savings. Because this measure considers HVLS fans as a replacement for multiple conventional, smaller fans, impacts to heating and cooling load are not quantified.

References

1. Kammel, David & Raabe, & Kappelman, J.. (2003). Design of high volume low speed fan supplemental cooling system in dairy freestall barns. Proceedings of the Fifth International Dairy Housing Conference. 10.13031/2013.11628.
   Available from:
   https://www.researchgate.net/publication/271433461_Design_of_high_volume_low_speed_fan_supplemental_cooling_system_in_dairy_freestall_barns
2. Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment, Building Technologies Office, US Department of Energy. December 2013.
   Available from:
   https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf
3. NOAA National Centers for Environmental Information
   Available from: https://www.ncdc.noaa.gov/cdo-web/search?datasetid=NORMAL_HLY
4. HVAC for Large Spaces: The Sustainable Benefits of HVLS (High Volume/Low Speed) Fans course, Continuing Education Center, Architecture + Construction
   Available from: https://continuingeducation.bnpmedia.com/courses/macroair-technologies/hvac-for-large-spaces-the-sustainable-benefits-of-hvls-high-volumelow-speed-fans/6/
5. Agricultural Ventilation Fans, Bioenvironmental and Structural Systems Laboratory, University of Illinois, Department of Agricultural and Biological Engineering, Accessed September 26, 2019
   Available from: http://www.bess.illinois.edu/current.asp

Record of Revision

Record of Revision Number	Issue Date
3-20-9	3/30/2020

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PROCESS EQUIPMENT

OZONE GENERATOR FOR ON-PREMISES LAUNDRY

Measure Description

This measure covers the addition of an ozone (O_3) generator to on-site commercial-grade laundry equipment, such as those found in hotels, nursing homes, health fitness centers and correctional facilities. Ozone helps break down soils into smaller molecules allowing simple agitation to release them from fabrics. As a result, ozone is a good alternative to conventional detergents and bleach, and allows washing machines to clean effectively using significantly less hot water. Using ozone in the wash cycle reduces the need for hot water and, in many situations, eliminates the need for hot water entirely. In addition, demonstration projects have found reductions in chemical and detergent use, as well as a reduction in overall water use.

This measure is only applicable to facilities with gas water heating.

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[61]

$$\Delta therms = \frac{(H_{set} - H_{main}) \times 8.33}{Eff_{boiler} \times 100{,}000} \times WUF \times HWUF \times HWRF \times Load$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
H_{set}	= Enthalpy of water at the hot water setpoint temperature (BTU/lb)
H_{main}	= Enthalpy of water at the main water supply temperature (BTU/lb)
Eff_{boiler}	= Thermal efficiency of the hot water boiler
WUF	= Washer Utilization Factor, a measure of the runtime of a typical laundry facility (lbs laundry/lbs capacity)
HWUF	= Hot Water Usage Factor, a measure of efficiency of baseline system (gal/lb)
HWRF	= Hot Water Reduction Factor
Load	= Washer capacity in pounds of laundry

[61] Pacific Gas & Electric Company, Work Paper PGECOAPP123, Ozone Laundry Nonresidential, Revision 6, August 22, 2017.

8.33 = Density of water (lb/gal)
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
H_{set}		From application. Enthalpies for certain water setpoint temperatures are listed in the Water Setpoint Enthalpy table below (°F).[62] Linear interpolation is permitted for water setpoint temperatures falling between provided temperatures.
H_{main}		Supply water enthalpy in water main. Lookup in Cold Water Inlet Enthalpy table below based on nearest city.
Eff_{boiler}	0.80	Thermal Efficiency of gas boiler.[63]
WUF	4,380	Washer Utilization Factor, a measure of washer user rate, median value from the California ozone laundry demonstration projects.[64]
HWUF	1.34	Hot Water Usage Factor, average hot water usage by baselines system per pound of laundry from the California demonstration projects.[65]
HWRF	0.86	Hot Water Reduction Factor, average reduction of hot water reduction due to the use of ozone from the California demonstration projects.[66]
Load		From application.

Water Setpoint Enthalpy (H_{set}) [67]

Water Setpoint Temperature (°F)	H_{set} (BTU/lb)	Water Setpoint Temperature (°F)	H_{set} (BTU/lb)
140	107.98	180	148.01
150	117.97	190	158.05
160	127.98	200	168.10
170	137.99		

Cold Water Inlet Enthalpy (H_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[68] Supply main enthalpies and temperatures based on the annual outdoor temperature are shown below.

[62] Enthalpy obtained from ASHRAE Fundamentals.
[63] 10 CFR 431.110 (a)
[64] PG&E Work Paper PGECOAPP123, Revision 4. Table 6.
[65] Ibid. Table 7
[66] Ibid. Table 8
[67] Enthalpy obtained from ASHRAE Fundamentals.
[68] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory

City	Annual average outdoor temperature[69] (°F)	Temperature Main (°F)	H_{main}[70] (BTU/lb)
Albany	48.3	54.3	22.37
Binghamton	46.3	52.3	20.37
Buffalo	48.3	54.3	22.37
Massena	43.5	49.5	17.57
NYC	55.4	61.4	29.48
Poughkeepsie	49.8	55.8	23.88
Syracuse	48.3	54.3	22.37

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing on-premises laundry facility using commercial grade laundry machines without an existing ozone generator, and either a natural gas boiler or natural gas water heater supplying hot water to the laundry equipment. The baseline efficiency of the water heating system is assumed to be 80% for these deemed measure savings.[71]

Compliance Efficiency from which Incentives are Calculated

The energy efficient condition is the addition of a new ozone generator to the on-premises laundry facility. The following specific requirements apply:

- The washing capacity of each washing machine supplied by the ozone generator must be rated at 200 pounds or less,
- Laundry systems equipped with tunnel washers are not eligible,
- The ozone laundry system must be a new purchased product and installed with either a new or existing commercial washing machine,
- The ozone laundry system must transfer ozone into the water with either a venturi injection or bubble diffusion process, and;
- The replacement an existing ozone generator, either operating or failed, does not qualify for this measure.

Operating Hours

The operating hours is captured in the utilization factor. The Washer Utilization Factor, a measure of the runtime of a typical laundry facility, as determined in California demonstration projects as the median value of the annual pounds of laundry washed divided by the washer's laundry capacity in pounds which equals 4,380.

[69] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals
[70] ASHRAE Fundamentals Handbook, saturated water based on temperature mains
[71] 10 CFR 431.110 (a)

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Additional electric energy is required to generate ozone in the efficient case. This is offset by pumping load savings resulting from a reduction in water consumption. As such, this methodology does not quantify these impacts.

References

1. Work Paper PGECOAPP123, Ozone Laundry Nonresidential, Revision 4, August 22, 2017. Pacific Gas & Electric Company, Customer Energy Solutions. Available from: http://deeresources.net/workpapers
2. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems Available from: https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
3. Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory. Available from: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=05D73BA6EF5ECCF71969D083FB317991?doi=10.1.1.515.6885&rep=rep1&type=pdf
4. U.S. Energy Information Administration, Updated Buildings Sector Appliance and Equipment Costs and Efficiencies, June 2018 Available from: https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf
5. 10 CFR 430 Subpart B Appendix E Uniform Test Method for Measuring the Energy Consumption of Water Heaters Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e

Record of Revisions

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3-20-13	3/30/2020

REFRIGERATION – CONTROL

FLOATING HEAD PRESSURE CONTROL

Measure Description

This measure covers the installation of refrigeration control to lower the condensing pressure on commercial refrigeration systems during times of ambient temperatures below 75°F. Systems are typically designed to have a constant saturated condensing temperature equivalent to approximately 95°F. By allowing the condensing pressure to drop during lower ambient conditions, the work on the refrigeration system is reduced, saving refrigeration system energy and prolonging the life of the equipment.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
(ΔkWh/hp) = kWh savings per refrigeration compressor horsepower
hp = Total refrigeration compressor horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
(ΔkWh/hp)		Lookup based on location, condenser type, temperature, and horsepower in Savings for Floating Head Pressure Controls table below.
hp		From application

Savings for Floating Head Pressure Controls (ΔkWh/hp)

System Type/Size	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Unitary Condenser, Low Temp, 0-3 hp	252.03	252.03	252.03	252.03	252.03	252.03	252.03
Unitary Condenser, Low Temp, >3-6 hp	241.86	241.86	241.86	241.86	241.86	241.86	241.86
Unitary Condenser, Low Temp, >6-10 hp	248.68	248.68	248.68	248.68	248.68	248.68	248.68
Unitary Condenser, Low Temp, >10 hp	282.24	282.24	282.24	282.24	282.24	282.24	282.24
Unitary Condenser, Medium Temp, 0-3 hp	131.45	131.45	131.45	131.45	131.45	131.45	131.45
Unitary Condenser, Medium Temp, >3-6 hp	127.32	127.32	127.32	127.32	127.32	127.32	127.32
Unitary Condenser, Medium Temp, >6-10 hp	128.1	128.1	128.1	128.1	128.1	128.1	128.1
Unitary Condenser, Medium Temp, >10 hp	132.58	132.58	132.58	132.58	132.58	132.58	132.58
Remote Condenser, Low Temp, 0-3 hp	669.58	716.77	668.31	672.30	505.37	563.20	672.70
Remote Condenser, Low Temp, >3-6 hp	637.37	682.29	636.16	639.96	481.06	536.11	640.34
Remote Condenser, Low Temp, >6-10 hp	642.54	687.83	641.32	645.15	484.96	540.45	645.54
Remote Condenser, Low Temp, >10 hp	666.86	713.86	665.60	669.57	503.32	560.91	669.97
Remote Condenser, Medium Temp, 0-3 hp	521.20	557.93	520.21	523.32	393.38	438.39	523.63
Remote Condenser, Medium Temp, >3-6 hp	513.45	549.63	512.47	515.53	387.53	431.87	515.84
Remote Condenser, Medium Temp, >6-10 hp	525.85	562.91	524.85	527.98	396.89	442.30	528.30
Remote Condenser, Medium Temp, >10 hp	536.15	573.93	535.13	538.32	404.66	450.96	538.65

Background on Derivation of Per Unit Savings

Annual energy savings for remote condenser units were derived by adjusting the savings values from the Regional Technical Forum, “Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems” to accommodate New York weather. NOAA data for Portland, OR and the seven cities/weather zones in NY; Albany, Binghamton, Buffalo, Massena, New York City, Poughkeepsie and Syracuse, was used to correlate the energy savings potential from Portland, OR to NY locations.

Based on the Regional Technical Forum, “Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems”, savings were based on the refrigeration compressor type along with the saturated suction temperature ranges and horsepower ranges for the evaporators.

The Regional Technical Forum, “Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems” classifies refrigeration compressors based on evaporator temperature ranges:

- Low Temperature (Freezer)
- Medium Temperature (Refrigerator)

The Regional Technical Forum, "Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems" classifies refrigeration compressors based on horsepower ranges:

- 0-3 hp
- > 3-6 hp
- > 6-10 hp
- > 10 hp

Portland, OR Annual Energy Savings for Remote Condenser Units based on Evaporator Temperature Range and Horsepower Range

System Type/Size	kWh/hp
Remote Condenser, Low Temp, 0-3 hp	534.90
Remote Condenser, Low Temp, >3-6 hp	509.17
Remote Condenser, Low Temp, >6-10 hp	513.30
Remote Condenser, Low Temp, >10 hp	532.73
Remote Condenser, Medium Temp, 0-3 hp	416.37
Remote Condenser, Medium Temp, >3-6 hp	410.17
Remote Condenser, Medium Temp, >6-10 hp	420.08
Remote Condenser, Medium Temp, >10 hp	428.31

A linear interpolation on energy savings from Portland, OR as a function of temperature was used to determine the energy savings in New York based on temperature bins. The two points used for interpolation were the point at/above which minimal savings occur, 75°F, and the average temperature below 75°F where the average kWh/hp savings is expected to occur, which varies by location.

Savings for unitary condensers are not adjusted for climate. This is because heat rejected by the system in these cases is rejected into the conditioned space, and therefore, refrigeration end use savings do not vary significantly by climate.

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A. It is assumed that NY temperatures below 75°F occur during non-summer peak hours.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a refrigeration system without floating head pressure controls; fixed head pressure typically set for approximately 95°F saturated condensing temperature, which correlates to approximately 82°F ambient temperature.

Compliance Efficiency from which Incentives are Calculated

The energy efficient condition is a refrigeration system that is controlled to allow the head pressure to float down during cooler ambient conditions.

Operating Hours

Operating hours are based on NOAA bin data for the seven cities/weather zones in NY; Albany, Binghamton, Buffalo, Massena, New York City, Poughkeepsie and Syracuse.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Regional Technical Forum, "Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems", workbook ComGroceryFHPCSingleCompressor_v2_1.xlsm, September 20, 2019. Available from: https://rtf.nwcouncil.org/measure/floating-head-pressure-controls-single-compressor-systems
2. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

Record of Revisions

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3-20-14	3/30/2020

Appliance

Fireplace

Measure Description

This measure covers the installation of direct-vented, gas fireplaces with fireplace efficiency (FE) greater than or equal to 70% tested in accordance with the Canadian Standards Association (CSA) CSA-P.4 method and electric, intermittent pilot lights. This measure is only applicable to the installation of gas fireplaces for use as a supplemental heat source.

This analysis leverages the DOE Technical Support Document (TSD) for baseline fireplaces and pilot lights and a survey of US utilities for efficient fireplaces.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \Delta kWh_{PilotLight}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left[\frac{kBTUh_{out}}{100} \times \left(\frac{1}{FE_{baseline}} - \frac{1}{FE_{ee}}\right) \times hrs + \Delta therm_{PilotLight}\right]$$

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
$\Delta kWh_{PilotLight}$	= Change in electric consumption of pilot light
$kBTUh_{out}$	= Output capacity of fireplace in kBTU/h
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
FE	= Rated efficiency of fireplace
hrs	= Annual operating hours of fireplace
$\Delta therm_{PilotLight}$	= Change in gas consumption of pilot light
100	= Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta kWh_{PilotLight}$	-13.6	Baseline direct, vented gas fireplaces with a standing pilot light consumes no electric energy but consumes gas energy. Intermittent pilot lights consume electricity but save gas.[72]
$kBTUh_{out}$		From application
$FE_{baseline}$	0.64	Average efficiency of baseline fireplace[73]
FE_{ee}		From application.
hrs	157	Annual hours of use of fireplace[74]
$\Delta therm_{PilotLight}$	34.9	Average therm savings from switching from baseline, standing pilot light to intermittent pilot light[75]

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is N/A. While there is an electric energy penalty due to the intermittent pilot light, there are no recommended demand savings due to fireplaces being operated during the heating season.[76]

Baseline Efficiencies from which Savings are Calculated

The baseline fireplace, as defined by DOE, is a direct-vented, gas fireplace with an FE of 64% and a standing pilot light.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a direct-vented gas fireplace with an FE of 70% or greater tested in accordance with the Canadian Standards Association (CSA) CSA-P.4 method and an intermittent pilot light.

Operating Hours

The operating hours are assumed to be 157 hours per year. This assumption is based on the average of the range of hearth product burner operating hours among sample households.[77]

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[72] DOE Technical Savings Document, Table 7.4.1: Average Annual Energy Consumption and Savings for Hearth Products

[73] DOE Technical Savings Document, page 7-7.

[74] DOE Technical Savings Document, Table 7.3.5: Range of Burner Operating Hours for Hearth Products

[75] DOE Technical Savings Document, Table 7.4.1: Average Annual Energy Consumption and Savings for Hearth Products

[76] Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Chapters 7 and 8. The most common form of electronic ignition system found in hearth products is the intermittent pilot ignition. In an intermittent pilot ignition, the pilot light is only lit when there is a call for heat, and the pilot light is automatically extinguished after the burner is turned off. In order to ignite the pilot light, these systems require an outside power source, often supplied by either a battery or an electrical connection.

[77] Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Table 7.3.5.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Electric Savings Impacts

N/A

Ancillary Fossil Fuel Savings Impacts

N/A

References

1. 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. Available from: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0036-0002.
2. A survey of US utilities offering rebates for high efficiency fireplaces and/or fireplaces with intermittent pilot lights found the minimum qualifying FE to be 70%. Utilities and organizations include Energy Trust of Oregon, CenterPoint Energy, Puget Sound Energy, Minnesota Energy Resources, and Dominion Energy Utah. Retrieved using *E-Source*.

Record of Revision

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12-19-4	12/23/2019
3-20-15	3/30/2020

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

ADVANCED BOILER CONTROL SYSTEM

Measure Description

This measure covers the installation of advanced boiler control systems in multi-family buildings with a central boiler system. An advanced boiler control system is designed for the automated control of the boiler's cycling time based on both indoor and outdoor temperatures. These systems utilize both indoor and outdoor temperature sensors along with remote monitoring to provide a real-time operating and energy consumption data on the building. Utilizing this data, the controls optimize the cycling operation of the boiler to better meet the demand for heat within the building.

These systems also have built-in communication software capable of connecting building operators to service providers in order to read, change, monitor, and analyze the system settings as well as receive diagnostic alerts in regards to equipment malfunctions, poor sensor readings, combustion inefficiencies, and other corrective actions needed. These services may be included up to a certain term, after which a service agreement is required.

In multifamily buildings, an advanced boiler control system installed with indoor temperature sensors in apartments and other heated spaces can reduce energy consumption by optimizing boiler operation based on seasonal weather variations, use patterns, and self-diagnostic functions.

This measure is only applicable to the retrofit of existing boiler control systems. An advanced boiler control system must be an upgrade over existing minimally code-compliant boiler control systems. Minimally code-compliant boiler control systems include an outdoor temperature setback control that controls the boiler's cycling time based only on the outdoor temperature. This measure must include a minimum of 25% apartment sensors as well as temperature sensors for the stack, DHW supply, outdoor weather, heating water supply or return, and condensate (steam). The advanced boiler control system must allow multiple boiler systems to have staging capability.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{BTU/h_{in}}{100{,}000} \times EFLH_{heating} \times ESF$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
Units = Number of measures installed under program
BTU/h_{in} = Boiler input rating
$EFLH_{heating}$ = Equivalent full-load hours
ESF = Energy Savings Factor for boiler control systems
100,000 = Conversion factor, (BTU/h)/therm

Summary of Variables and Data Sources

Variable	Value	Notes
BTU/h_{in}		From application, boiler input rating, in BTU/h.
$EFLH_{heating}$		Lookup based on building type and location.
ESF	0.10	Energy Savings Factor[78]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is an existing multi-family residential boiler with a control system based on outdoor temperature reset.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the new installation of an Advanced Boiler Control System with the capability of controlling an existing multi-family boiler based on indoor and outdoor temperature.

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

[78] Con Edison EEPS Programs – Con Ed Multifamily Program, Program Year 2017 Impact Evaluation, December 11, 2019.

Ancillary Electric Savings Impacts

N/A

References

1. Con Edison EEPS Programs – Con Ed Multifamily Program, Program Year 2017 Impact Evaluation, December 11, 2019.

Record of Revision

Record of Revision Number	Issue Date
3-20-16	03/30/2020

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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[79]
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[80]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[81]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[82]
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[83]
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

79 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
80 ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
81 ENERGY STAR® Dehumidifier Calculator https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
82 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
83 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[84]
	Air Leakage Sealing	Residential	15	GDS[85]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[86]
	Insulation – Opaque Shell	Residential	25	GDS[87]
	Storm Window	Residential	20	DOE[88]
	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[89]
	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[90]
Domestic Hot Water - Control	Drain Water Heat Recovery	Residential	30	2019 Title 24[91]
	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[92]

84 At least one manufacturer’s warranty period. www.gss-ee.com/products.html
85 GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
86 Ibid.
87 Ibid.
88 https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
89 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
90 https://www.energy.gov/energysaver/solar-swimming-pool-heaters
91 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
92 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[93]
	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[94]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER[95]
	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[96,97]
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP

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

[94] 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

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

[96] 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

[97] 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[98]
	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[99]
	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[100]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[101]

[98] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[99] NYSERDA Residential Electric Submetering Manual
[100] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. Cost-Benefit Financial Assumptions, pg. 16
[101] 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[102]
			50,000 hours	DLC[103]

[102] 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

[103] 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[104]
		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[105]

[104] 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

[105] 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[106]

[106] 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[107]
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[108]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[109]
	Cooking Equipment[110]	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[111]
	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[112]
	Insulation - Opaque Shell	C&I	30	ET & CEC[113]
	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

[107] PG&E Work Paper PGE3PAGR117, October 12, 2017
[108] Based on EUL's for Advanced Power Strips
[109] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[110] Applicable to all kitchen cooking equipment not otherwise listed
[111] 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
[112] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[113] 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[114]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[115]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study C&I Retrofit EUL[116]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [117]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [118]
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[119]
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[120]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER[121]

[114] 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.
[115] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[116] 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
[117] 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.
[118] Ibid.
[119] https://www.nrel.gov/docs/fy16osti/64541.pdf
[120] 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
[121] 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[122]
	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[123],[124]
	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[125]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[126]
	Infrared Heater	C&I	17	GDS[127]

122 Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)

123 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

124 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

125 ASHRAE Owning and Operating Cost Database
Available from: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

126 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

127 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[128]
	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[129]
	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[130]
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[131]

[128] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[129] PG&E Work Paper WPSDGENRCC0019, June 15, 2012
[130] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf
[131] 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®[132]
		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®[133]
		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®[134]
		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

[132] 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

[133] 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

[134] 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[135]
			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[136]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[137]
	Integrated Interior Lighting Control	C&I	15	ComEd[138]
	Non-Integrated Interior Lighting Control	C&I	10	GDS[139]
	Plug-Load Occupancy Sensor	C&I	8	DEER[140]
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[141]
Other	Pool Heater	C&I	8	DOE[142]

135 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

136 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

137 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

138 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

139 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

140 DEER value for lighting occupancy sensors

141 Assumes same EUL as VFD measure.

142 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[143]
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 [144]

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

[143] PG&E Work Paper PGECOAPP123, August 22, 2017
[144] 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
ºF	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 ºF 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 @ 70ºF × 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

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0	12/10/2014
6-15-4	6/1/2014
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9-17-12	9/30/2017
12-17-18	12/31/2017
3-18-22	3/29/2018
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