Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-1	R	6/26/2018	1/1/2019	R/MF Dishwasher	Revised Measure Description to reflect language related to ENERGY STAR® equipment; Updated savings estimation methodology to align with ENERGY STAR® calculator; Added water heating fuel type adjustment factors; Updated Coincidence Factor; Added Baseline and Compliance Efficiency detail in accordance ENERGY STAR®; Added detail to Operating Hours section; Revised EUL source	Pg. 21
6-18-2	R	6/26/2018	1/1/2019	R/MF Hot Water Pipe Insulation	Added language to Measure Description to restrict measure material, pipe diameter and installation conditions; Updated variable values, references, labels and definitions for consistency with other measures; Added water heating fuel type adjustment factors; Updated Coincidence Factor; Revised Baseline and Compliance Efficiency requirements and UA/L values; Updated Operating Hours section; Revised EUL source/value	Pg. 41
6-18-3	R	6/26/2018	1/1/2019	R/MF Air Conditioner and Heat Pump – Refrigerant Charge Correction	Changed Measure Name and Measure Description to include system tune-up requirement; Revised approach to include HP heating savings; Added provisions for estimate of savings for small and large equipment; Removed default efficiency values; Updated Coincidence Factor; Edited Baseline Efficiency section to clarify application of derating factors, tabulated values and included approach for multi-circuit systems; Added detail to Compliance Efficiency and Operating Hours sections; Revised EUL source	Pg. 99

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-4	R	6/26/2018	1/1/2019	R/MF Circulator Pump – with Electronically Commutated (EC) Motor, for Hydronic Distribution	Restricted measure to retrofit only; Added load factor to methodology; Added provisions for estimating peak demand savings; Added provisions for cooling systems; Updated baseline and qualifying efficiency and operating hours assumptions; Updated Coincidence Factor; Added detail in Compliance Efficiency, Operating Hours, and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 108
6-18-5	R	6/26/2018	1/1/2019	R/MF Duct Sealing and Insulation	Restricted measure to existing buildings, ductwork in unconditioned spaces and code compliance or better for eligibility; Required pre and post-implementation duct blaster testing; Added terms to equation to account for portion of ductwork located in unconditioned spaces; Added provisions for estimate of savings for small and large equipment and electric furnaces; Added cooling/heating Thermal Regain Factor adjustments; Removed default efficiency values; Updated Coincidence Factor; Revised Compliance Efficiency section to reflect minimum code requirement; Revised EUL source	Pg. 110
6-18-6	R	6/26/2018	1/1/2019	R/MF Outdoor Reset Control for Hydronic Boiler	Revised Measure Name to “Setback Control” instead of “Reset Control”; Clarified restriction to retrofit of existing boilers only; Removed default boiler capacity section, requiring actual boiler input for calculation; Updated Baseline Efficiency and Compliance Efficiency sections; Revised EUL to reflect the remaining useful life of the existing boiler	Pg. 133

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-7	R	6/26/2018	1/1/2019	C/I Vending Machine and Novelty Cooler Time Clock	Revised Measure Name to accommodate occupancy sensing controls and updated Measure Description to clarify application and restrictions; Updated approach for establishing operating hours; Added detail to Baseline Efficiency, Compliance Efficiency, Operating Hours and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 165
6-18-8	R	6/26/2018	1/1/2019	C/I Air Dryer - Refrigerated	Updated Measure Description to clarify application and restrict to single compressor systems; Revised assumed ΔkW/CFM value; Added peak operation Boolean; Revised EUL source	Pg. 182
6-18-9	R	6/26/2018	1/1/2019	C/I Faucet – Low Flow Aerator	Added restriction to Measure Description for public lavatories and applied general language updates; Revised presentation of methodology and variable terms and definitions to align with other measures; Added flow restriction adjustment factors; Updated usage/operating assumptions; Added detail to Baseline Efficiency, Qualifying Efficiency and Operating Hours sections; Included table of default days per year by facility type; Revised EUL source	Pg. 198
6-18-10	R	6/26/2018	1/1/2019	C/I Air Conditioner and Heat Pump – Refrigerant Charge Correction	Changed Measure Name and Measure Description to include system tune-up requirement; Revised approach to include HP heating savings; Added provisions for estimate of savings for small and large equipment; Removed default efficiency values; Edited Baseline Efficiency section to clarify application of derating factors, tabulated values and included approach for multi-circuit systems; Added detail to Compliance Efficiency and Operating Hours sections; Revised EUL source	Pg. 209

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-12	R	6/26/2018	1/1/2019	C/I Motor Replacement	Revised Measure Description to include phase/size/speed restrictions and compliance requirements; Updated savings estimation approach to assume equivalent power rating pre and post; Added detail to Baseline and Compliance Efficiency sections; Added default operating hours by application and facility type to Operating Hours section; Added Ancillary Fossil Fuel/Electric Savings Impacts language; Revised EUL source	Pg. 274
6-18-13	R	6/26/2018	1/1/2019	C/I Electronically Controlled Brushless Permanent Magnet (BPM) Motors for HVAC Circulation (Blower) Fan	Revised Measure Name and Measure Description to refer to Electronically Commutated Motors; Defined baseline condition as single-speed PSC motors; Updated variable terms and definitions for consistency with other measures; Removed default wattage table; Added detail to Baseline Efficiency, Compliance Efficiency, Operating Hours and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 280
6-18-14	R	6/26/2018	1/1/2019	C/I Freezer and Cooler Door Gaskets	Modified Measure Description to clarify application; Revised algorithms and variable terms and definitions for consistency with other measures; Updated assumed ΔkWh/ft values; Updated Coincidence Factor; Revised Baseline Efficiency section; Added detail to Operating Hours and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 294
6-18-21	R	6/26/2018	1/1/2019	Appendix P[1]	Updated EUL entries for all measures contained in this Record of Revision.	Pg. 577

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

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-22	R	6/26/2018	1/1/2019	Glossary[2]	Added entries to align with all measures contained in this Record of Revision.	Pg. 588

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

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

DISHWASHER

Measure Description

This measure covers the installation of ENERGY STAR® qualified residential dishwashers.[1] A dishwasher is a cabinet-like appliance that, with the aid of water and detergent, washes, rinses, and dries (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, mechanical and/or electrical means and discharges to the plumbing drainage system. ENERGY STAR® rated machines run more efficiently while washing dishes through improved technology such as soil sensors, improved water filtration, more efficient jets, and innovative dish rack designs. Qualified dishwashers are 12% more efficient than non-certified models.[2]

This measure only applies to standard and compact residential grade equipment, as defined below.

Standard Dishwasher – A dishwasher that has a capacity equal to or greater than eight place settings plus six serving pieces as specified in ANSI/AHAM DW-1-2010 (incorporated by reference; see §430.3), using the test load specified in section 2.7 of 10 CFR 430, Subpart B, Appendix C1.[3]

Compact Dishwasher – A dishwasher that has a capacity of less than eight place settings plus six serving pieces as specified in ANSI/AHAM DW-1-2010 (incorporated by reference; see §430.3), using the test load specified in section 2.7 of 10 CFR 430, Subpart B, Appendix C1.[4]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times [(kWh_{baseline} - kWh_{ee}) \times (F_{machine} + F_{wh} \times ElecSF_{wh})]$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times (kWh_{baseline} - kWh_{ee}) \times F_{wh} \times GasSF_{wh} \times \frac{RE_{elec}}{RE_{gas}} \times \frac{3{,}412}{100{,}000}$$

[1] ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers Eligibility Criteria Version 6.0, January 2016
[2] Efficiency of ENERGY STAR® Dishwashers (accessed 4/4/2018) https://www.energystar.gov/products/appliances/dishwashers
[3] 10 CFR 430, Subpart B, Appendix C1
[4] Ibid

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
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
kWh	= Annual rated electric energy use
$F_{machine}$	= Fraction of energy used for the dishwasher machine
F_{wh}	= Fraction of energy used for the water heater
$ElecSF_{wh}$	= Electric Savings Factor for water heaters
$GasSF_{wh}$	= Gas Savings Factor for water heaters
RE_{elec}	= Recovery efficiency of electric water heater
RE_{gas}	= Recovery efficiency of gas water heater
CF	= Coincidence factor
3,412	= Conversion factor, one kWh equals 3,412.14 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		Look up based on Dishwasher Type in Baseline Efficiencies section below.
kWh_{ee}		From application.
F_{wh}	0.56[5]	
$F_{machine}$	0.44[6]	
$ElecSF_{wh}$	Electric WH: 1.00 Gas WH: 0 Other: 0 Unknown*: 0.31	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[7]
$GasSF_{wh}$	Electric WH: 0 Gas WH: 1.00 Other: 0 Unknown*: 0.56	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[8]
RE_{elec}	0.98	Recovery efficiency of typical electric storage type water heater. [9]

[5] ENERGY STAR® Appliance Calculator
[6] Ibid
[7] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7 ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating)
[8] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7 ("Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating)
[9] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

Variable	Value	Notes
RE_{gas}	0.75	Recovery efficiency of typical gas storage type water heater.[10]
hrs	301[11]	
CF	0.026	

*"Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration or delivery mechanism

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.031.[12]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a residential dishwasher as defined in the Measure Description section above with type equivalent to the proposed case meeting the minimum effective federal performance standards. The baseline water heating system is a standard efficiency storage type electric or gas system (fuel type equivalent to the actual existing condition). Current federal annual energy consumption performance standards for dishwashers are provided in the table below.[13]

Dishwasher Type	$kWh_{baseline}$
Compact	222
Standard	307

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified residential dishwasher as defined in the Measure Description section above. Qualifying equipment must have rated annual energy consumption at or below the ENERGY STAR qualified specifications as indicated the table below, based on dishwasher type.[14] Energy rating is to be taken from application.

Dishwasher Type	kWh_{ee}
Compact	203
Standard	270

[10] Per 10 CFR 430, typical recovery efficiency of a gas water heater is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[11] 10 CFR 430 Appendix C1 (5) Uniform Test Method for Measuring the Energy Consumption of Dishwashers
[12] Based on 8760 end use data for Missouri, provided to VEIC by Ameren for use in the Illinois TRM. The average dishwasher load during peak hours is divided by the peak load. In the absence of a New York specific load shape, this is deemed a reasonable proxy because load shapes are not expected to vary significantly by region. Data from Ameren was adjusted to account for the difference in assumed annual operating hours (252 hours were used in the referenced study whereas 301 hours are cited in this document).
[13] 10 CFR 430.32 (f)(1)
[14] ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers Eligibility Criteria Version 6.0, January 2016, Table 1: Annual Energy Consumption Base Allowances

Operating Hours

An average of 215 annual 1.4-hour dishwasher cycles is assumed in order to estimate conventional and qualifying energy ratings, for a total of 301 hours of active use per year. [15]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers, Eligibility Criteria Version 6.0, January 2016
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements_0.pdf
2. ENERGY STAR® Certified Products, Appliances, Dishwashers
   Available from: https://www.energystar.gov/products/appliances/dishwashers
3. 10 CFR 430 Subpart B Appendix C1 Uniform Test Method for Measuring the Energy Consumption of Dishwashers
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=aae04a703cdc86ce4c2f95a211f420f2&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.c1
4. Savings calculator for ENERGY STAR® Qualified Appliances
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
5. EIA Residential Energy Consumption Survey (RECS) 2015 Survey Data for Middle Atlantic States.
   Available from:
   https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.7.php
6. 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

[15] 10 CFR 430 Appendix C1 (5) Uniform Test Method for Measuring the Energy Consumption of Dishwashers

7. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=c46beaae860c6caba80d2be690e27cac&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-18-1	6/26/2018

Return to Table of Contents

HOT WATER AND STEAM PIPE INSULATION

Measure Description

This measure covers the installation of fiberglass, rigid foam and cellular glass pipe insulation on uninsulated copper or steel piping with a nominal diameter between 0.75" and 4.00" in hot water and steam space heating and domestic hot water (DHW) distribution systems. Claimed savings depend on the type and size of the pipe, type and thickness of the insulation, hot water temperature and ambient temperature.

This measure is applicable in retrofit applications only and must be installed by a qualified contractor complying with all relevant construction and safety codes and standards. All insulation materials installed under this measure are to be tested and rated in accordance with all pertinent ASTM thermal insulation standards. This measure is restricted to lengths of existing uninsulated piping in unconditioned spaces only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,elec} \times 3{,}412} \times L \times \Delta T \times hrs \times ElecSF$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,gas} \times 100{,}000} \times L \times \Delta T \times hrs \times GasSF$$

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
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient measure
(UA/L)	= Overall heat transfer coefficient per unit length (BTU/hr-°F-ft)
E_t	= Thermal efficiency of hot water source
L	= Length of installed insulation (ft)
ΔT	= Temperature difference between hot water in pipe and surrounding ambient air temperature (°F)
hrs	= Annual operating hours

ElecSF = Electric Savings Factor: Adjustment to electric energy savings based on fuel type
GasSF = Gas Savings Factor: Adjustment to gas energy savings based on fuel type
CF = Coincidence factor
3,412 = Conversion factor, one kW equals 3,412.14 BTU/h
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
$(UA/L)_{baseline}$		Lookup from Baseline Efficiencies section below, based on pipe diameter, pipe material and application.
$(UA/L)_{ee}$		Lookup from Compliance Efficiency section below, based on pipe diameter and insulation type and thickness.
$E_{t,elec}$	DHW: 0.98	Recovery efficiency of typical electric storage type water heater.[1]
$E_{t,gas}$	DHW: 0.75[2] HW Boiler: 0.82 AFUE[3] Steam Boiler: 0.80 AFUE[4]	Recovery efficiency of typical gas storage type water heater and baseline efficiency of residential-size space heating boilers.
L		From application
ΔT	$T_{pipe} - T_{amb}$	
T_{pipe}	DHW: 140[5] HW Boiler: 160 Steam Boiler: 212	Average temperature of hot water in distribution system piping (°F).
T_{amb}	DHW: 70[6] Space Heat: 50[7]	Surrounding average ambient air temperature (°F).
ElecSF	Electric DWH: 1.00 Gas DWH: 0 Unknown DWH*: 0.31 Space Heat: 0	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[8]

[1] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*
[2] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[3] 10 CFR 430.32(e)
[4] 10 CFR 430.32(e)
[5] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/dts/osta/otm/legionnaires/hotwater.html)
[6] Average annual ambient temperature in unconditioned spaces
[7] Average ambient temperature based on typical heating season conditions of unconditioned basements
[8] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7, Fuel used by main water heater ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating)

Variable	Value	Notes
GasSF	Electric DWH: 0 Gas DWH: 1.00 Unknown DWH*: 0.56 Space Heat: 1.00	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[9]
hrs	DHW: 8,760 Space Heat: $EFLH_{heating}$ (Appendix G)	See Operating Hours section below.

*"Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration or delivery mechanism

Coincidence Factor (CF)

The recommended value for the coincidence factor for domestic water heating is 1.0.[10]
The recommended value for the coincidence factor for space heating is N/A.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a length of uninsulated copper or steel domestic hot water or space heating piping located in an unconditioned space. Prescribed $(UA/L)_{baseline}$ values are provided in the table below based on the diameter of pipe, pipe material, and application. Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Values were developed using NAIMA's 3E Plus software program.[11] Insulation of CPVC, PEX and HDPE piping is not eligible for savings claims under this measure; however, these pipe materials are under evaluation for future inclusion.

Pipe Diam. (in)	$(UA/L)_{baseline}$				
	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45
4.00	1.98	2.14	2.40	2.43	2.73

[9] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7, fuel used by main water heater ("Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating)
[10] *No source specified – update pending availability and review of applicable references.*
[11] Insulation Institute, 3E Plus® Version 4.1

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a length of copper or steel service hot water or space heating hot water/steam distribution piping insulated in accordance with ECCCNYS[12] and NYCECC[13], which require hot water piping with 0.75" nominal diameter and larger to be insulated with a minimum thermal resistance of R-3. The R-value is the thermal resistance of the insulating material, which is derived by dividing the thickness of the material by the material's thermal conductivity, or k-value. Thermal transmittance, or the material's U-factor, is the inverse of the R-value.

The $(UA/L)_{ee}$ values associated with fiberglass, rigid foam and cellular glass insulation of various thicknesses provided in the table below shall be used to establish the compliance condition heat transfer coefficient. Pipe diameter and insulation type and thickness shall be taken from the application. The values below were calculated using a k-value of 0.25 BTU-in/hr-°F-ft^2 for fiberglass and 0.35 BTU-in/ hr-°F-ft^2 for rigid foam and cellular glass insulation at 100°F. Pipe wall resistance and exterior film resistance were ignored in the derivation of the values below. Values were developed using NAIMA's 3E Plus software program.[14]

Pipe Diam. (in)	**$(UA/L)_{ee}$**											
	Fiberglass						**Rigid Foam/Cellular Glass**					
	0.5 in	**1 in**	**1.5 in**	**2 in**	**2.5 in**	**3 in**	**0.5 in**	**1 in**	**1.5 in**	**2 in**	**2.5 in**	**3 in**
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19

Operating Hours

Domestic hot water heaters are assumed to be available for operation 8,760 hours per year.

Operating hours for water and steam boilers in space heating systems are established on the basis of equivalent full-load 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 by location, building type and vintage are tabulated in Appendix G.

[12] ECCCNYS 2016, R403.5.3
[13] NYCECC 2016, R403.5.3
[14] Insulation Institute, 3E Plus® Version 4.1

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
2. 10 CFR 430 Subpart B – Test Procedures, Appendix C1 - Uniform Test Method for Measuring the Energy Consumption of Dishwashers
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=9acb5e05dd1d96230c64079cf0c03102&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.c1
3. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
4. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from: https://www.osha.gov/dts/osta/otm/legionnaires/hotwater.html
5. EIA Residential Energy Consumption Survey (RECS) 2015 Survey Data for Middle Atlantic States, February 2015
   Available from:
   https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.7.php
6. 3E Plus, NAIMA, Insulation Institute, Version 4.1
   Available from: https://insulationinstitute.org/tools-resources/free-3e-plus/
7. ECCCNYS 2016, per IECC 2015; R403.5.3 Hot water pipe insulation (Prescriptive)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency
8. NYCECC 2016; R403.5.3 Hot water pipe insulation (Prescriptive)
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-15	7/31/2013
6-18-2	6/26/2018

Return to Table of Contents

REFRIGERANT CHARGE CORRECTION & TUNE UP – AIR CONDITIONER AND HEAT PUMP

Measure Description

This measure estimates savings associated with refrigerant charge correction for unitary and split system air conditioners and heat pumps in single and multi-family residential applications. In order to be eligible for savings claims, the scope of work performed must include manufacturer recommended AC tune-up procedures including but not limited to the cleaning of the condenser coils.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For Units with Cooling Capacity < 65,000 Btu/h

$$\Delta kWh = units \times \begin{bmatrix} \left(tons/unit \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling}\right) \\ + \\ \left(kBTUh_{out}/unit \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}\right) \end{bmatrix}$$

For Units with Cooling Capacity ≥ 65,000 Btu/h

$$\Delta kWh = units \times \begin{bmatrix} \left(tons/unit \times \left(\frac{12}{IEER_{baseline}} - \frac{12}{IEER_{ee}}\right) \times EFLH_{cooling}\right) \\ + \\ \left(\frac{kBTUh_{out}/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right) \end{bmatrix}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

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
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)

$kBTUh_{out}$/unit = Output heating capacity in kBTUh (at AHRI standard high-temperature rating conditions)
ee = Energy efficient condition or measure
baseline = Baseline condition or measure
SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
IEER = Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions (used only for units with cooing capacity ≥ 65,000BTU/h)
EER = Energy efficiency ratio under peak conditions, measurement of cooling capacity for a unit (in Btu/hour) / electrical energy used (watts) (at AHRI standard rating conditions)
HSPF = Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP = Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$EFLH_{cooling}$ = Equivalent full-load cooling hours
$EFLH_{heating}$ = Equivalent full-load heating hours
CF = Coincidence factor
12 = kBTUh/ton of air conditioning capacity
3.412 = Conversion factor, one watt-hour equals 3.412 BTU

Summary of Variables and Data Sources

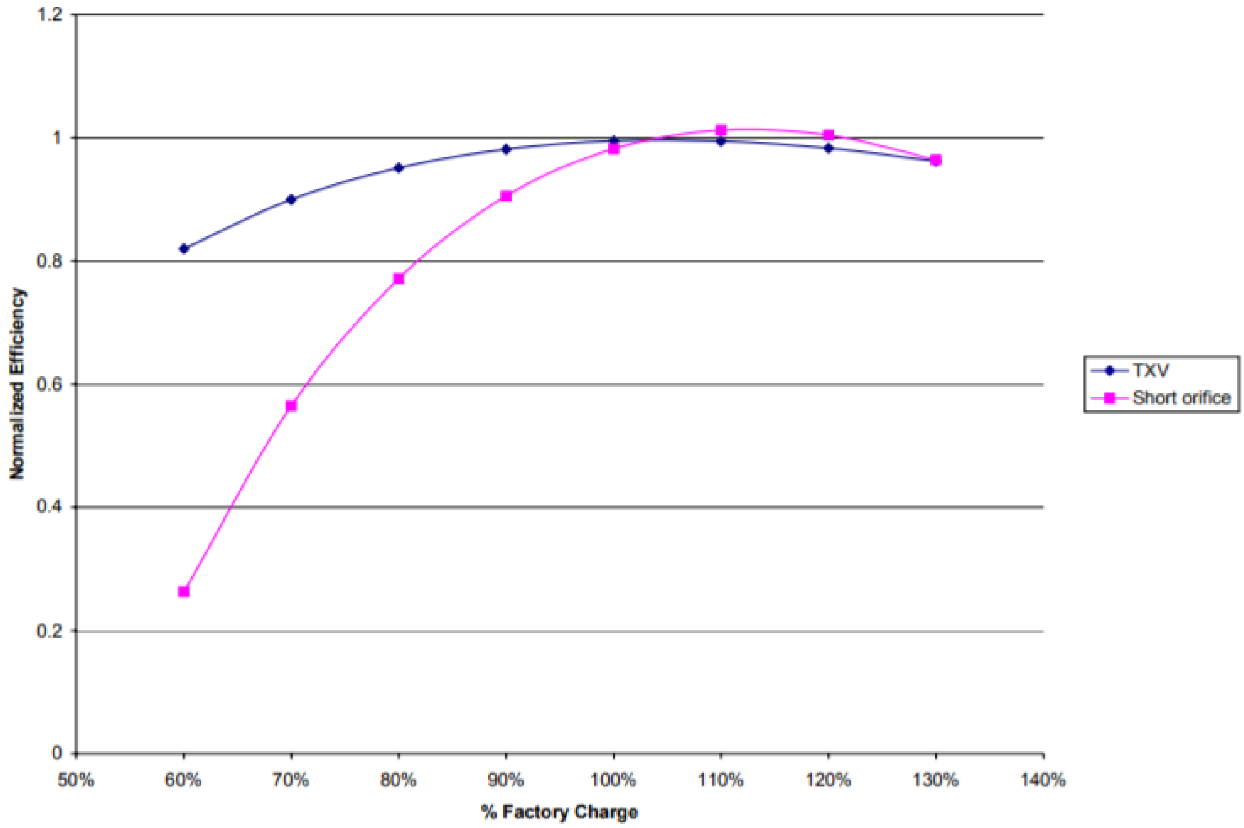
Variable	Value	Notes
tons/unit		From application.
$kBTUh_{out}$		From application.
$SEER_{ee}$		Actual equipment nameplate SEER.
$SEER_{baseline}$		Actual equipment nameplate SEER, derated in accordance with the Baseline Efficiency section below.
$IEER_{ee}$		Actual equipment nameplate IEER.
$IEER_{baseline}$		Actual equipment nameplate IEER, derated in accordance with the Baseline Efficiency section below.
EER_{ee}		Actual equipment nameplate EER.
$EER_{baseline}$		Actual equipment nameplate EER, derated in accordance with the Baseline Efficiency section below.
$HSPF_{ee}$		Actual equipment nameplate HSPF.
$HSPF_{baseline}$		Actual equipment nameplate HSPF, derated in accordance with the Baseline Efficiency section below.
COP_{ee}		Actual equipment nameplate COP.
$COP_{baseline}$		Actual equipment nameplate COP, derated in accordance with the Baseline Efficiency section below.
$EFLH_{cooling}$		Look up based on building type, vintage and location in Appendix G.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
CF	0.69	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.69.[1]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is equivalent to the existing condition with efficiency ratings taken from the actual equipment nameplate, derated to account for under or overcharging. The efficiency improvement resulting from refrigerant charge adjustment is dependent upon the discrepancy between the actual equipment charge before the adjustment was performed and the manufacturer's specification. The efficiency adjustment factor as a function of charge adjustment is taken from the figure or table below.[2] Note the efficiency change depends on the type of expansion valve. Use the curve or column labeled "TXV" for units with thermal expansion valves; otherwise use the curve or column labeled "Short orifice".



[1] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the TRM Management Committee.

[2] Efficiency as a function of charge adjustment from Small HVAC System Design Guide, New Buildings Institute, 2003

% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)	% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)
60%	0.26	0.82	96%	0.96	0.99
62%	0.32	0.84	98%	0.97	0.99
64%	0.39	0.85	100%	0.98	1.00
66%	0.45	0.87	102%	0.99	1.00
68%	0.51	0.89	104%	1.00	1.00
70%	0.56	0.90	106%	1.00	1.00
72%	0.61	0.91	108%	1.00	1.00
74%	0.66	0.92	110%	1.00	1.00
76%	0.70	0.93	112%	1.00	0.99
78%	0.73	0.94	114%	1.00	0.99
80%	0.77	0.95	116%	1.00	0.99
82%	0.80	0.96	118%	1.00	0.99
84%	0.83	0.97	120%	1.00	0.99
86%	0.86	0.97	122%	1.00	0.98
88%	0.88	0.98	124%	0.99	0.98
90%	0.91	0.98	126%	0.98	0.97
92%	0.92	0.99	128%	0.97	0.97
94%	0.94	0.99	130%	0.96	0.96

If the equipment is a multi-circuit system, the overall efficiency adjustment shall be calculated as the sum of each circuit's derating factor multiplied by its percentage of the total system capacity. For example, the equation for $EER_{baseline}$ is shown below:

$$EER_{baseline} = EER_{ee} \times \sum_{n} (\%Cap_n \times Fderate_n)$$

where:

n = Each circuit
%Cap = Percentage capacity of total
Fderate = Derating factor, normalized efficiency from figure/table above

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential air-cooled unitary or split system air conditioner or heat pump that has undergone a tune up involving a refrigerant charge correction. SEER, IEER, EER, HSPF, and COP values are taken from application as reported on the equipment nameplate or manufacturer specifications.

Operating Hours

For central air conditioners and heat pumps, look up EFLH data by location, building type and vintage from Appendix G. The oversizing assumptions embedded in the Appendix G data are appropriate for equipment sized to meet the peak-cooling load for central air conditioners and air source heat pumps.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. Small HVAC System Design Guide, New Buildings Institute, White Salmon, WA for the California Energy Commission.
   Available from: http://www.energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-12.PDF

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-3	6/26/2018

Return to Table of Contents

CIRCULATOR PUMP – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR, FOR HYDRONIC DISTRIBUTION

Measure Description

This measure covers the retrofit of standard efficiency permanent split capacitor (PSC) motors with electronically commutated (EC) motors in hydronic distribution circulators in residential heating and cooling systems. A circulator pump is a specific type of pump used to circulate liquids in a closed distribution system. They are commonly found circulating water in a hydronic heating or cooling system.

Circulator pumps used in hydronic systems are usually electrically powered centrifugal pumps. When used in homes, they are often small, sealed, and rated at a fraction of a horsepower. The sealed units used in home applications often have the motor rotor, pump impeller, and support bearings combined and sealed within the water circuit. This avoids one of the principal challenges faced by the larger, two-part pumps: maintaining a water-tight seal at the point where the pump drive shaft enters the pump body.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hp \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) \times LF \times 0.746\ (kW/hp) \times hrs$$

Peak Coincident Demand Savings

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

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
units	= Number of measures installed under the program
hp	= Proposed circulator motor horsepower
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
Eff	= Efficiency
LF	= Load factor
hrs	= Annual hours of operation
CF	= Coincidence factor
0.746	= Conversion factor (kW/hp), 746 watts equals one electric horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application.
$Eff_{baseline}$	0.60	Baseline PSC motor efficiency[1]
Eff_{ee}	0.80	Proposed EC motor efficiency[2]
LF	0.9[3]	
hrs	Heating = 3,504[4] Cooling = 2,208[5]	
CF	Heating = N/A Cooling = 0.8	

Coincidence Factor (CF)

The recommended value for the coincidence factor for heating is N/A.
The recommended value for the coincidence factor for cooling is 0.8.[6]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a hydronic circulator pump operating with a standard permanent split-capacitor (PSC) motor in a residential heating and/or cooling system.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a hydronic circulator pump operating with a high efficiency EC motor in a residential heating and/or cooling system. High efficiency circulators may include better impeller design that will further increase kWh savings, but these benefits are not considered in the prescribed savings estimation methodology.

Operating Hours

Annual circulator operating hours in a hydronic heating system are assumed to be 3,504, based on assumed 40% utilization of circulator pump. Savings will be less if the circulator cycles on and off with calls for heating.

Annual circulator operating hours in a hydronic cooling system are assumed to be 2,208, reflective of utilization of cooling systems for three months out of the year.

---

[1] 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.
[2] ACHR News, Comparing Motor Technologies, December 2009
[3] *No source specified – assumed value to reflect that motors do not typically run at 100% of rated power.*
[4] Assessment of New Energy Efficient Circulator Pump Technology, pg 4-3. Assumed circulator pump is utilized 40% of the year (0.40*8,760 = 3,504).
[5] Assumes three months (92 days) of 24-hour operation.
[6] *No source specified – update pending availability and review of applicable references.*

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Higher efficiency circulators may lead to increased gas consumption. Reduction in waste heat from increased efficiency in motors results in additional heating requirement. These effects are not quantified in this methodology.

Ancillary Electric Savings Impacts

Higher efficiency circulators may lead to reduced electric consumption. Reduction in waste heat from increased efficiency in motors results in decreased cooling requirement. These effects are not quantified in this methodology.

References

1. 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
2. ACHR News, Comparing Motor Technologies, December 2009 Available from: https://www.achrnews.com/articles/112674-comparing-motor-technologies
3. Assessment of New Energy Efficient Circulator Pump Technology, Electric Power Research Institute, November 2010 Available from: https://publicdownload.epri.com/PublicDownload.svc/product=000000000001020132/type=Product

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-18-4	6/26/2018

Return to Table of Contents

DUCT SEALING AND INSULATION

Measure Description

This measure covers the installation of sealing and insulation of the space heating and air conditioning duct distribution system in the unconditioned spaces of single-family and multi-family homes. Duct sealing and insulation reduces air and thermal leakage into unconditioned and outdoor spaces, improving system efficiency. Sealing and insulation installed under this measure shall meet or exceed all applicable construction code requirements. This measure is only applicable in existing buildings. Only ductwork located in unconditioned spaces is eligible for savings.

This measure shall be implemented with the assistance of a duct-blaster test on the distribution system pre and post-implementation. A duct blaster test, similar in concept to a whole-house blower door test, is turned on to pressurize the duct system to 25 Pascal's (a pressure which represents typical operating pressures for forced-air systems). The airflow through the duct blaster fan (which is displayed in cfm on the duct blaster's manometer) equals the flow escaping through leaks in the duct system. The results are reported as "cfm @ 25 Pascal's".

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For AC and HP Units with Capacity <65,000 BTUh

$$\Delta kWh = \frac{L_{duct,uncond}}{L_{duct}} \times \left[\begin{array}{c} \left(tons \times \frac{12}{SEER} \times EFLH_{cooling} \times \left(1 - \frac{\eta_{dist,cooling,baseline}}{\eta_{dist,cooling,ee}}\right)\right) \times (1 - TRF_{cooling}) \\ + \\ \left(kBTUh_{out} \times \frac{1}{HSPF} \times EFLH_{heating} \times \left(1 - \frac{\eta_{dist,heating,baseline}}{\eta_{dist,heating,ee}}\right)\right) \times (1 - TRF_{heating}) \end{array} \right]$$

For AC and HP Units with Capacity ≥65,000 BTUh

$$\Delta kWh = \frac{L_{duct,uncond}}{L_{duct}} \times \left[\begin{array}{c} \left(tons \times \frac{12}{IEER} \times EFLH_{cooling} \times \left(1 - \frac{\eta_{dist,cooling,baseline}}{\eta_{dist,cooling,ee}}\right)\right) \times (1 - TRF_{cooling}) \\ + \\ \left(\frac{kBTUh_{out}}{3.412} \times \frac{1}{COP} \times EFLH_{heating} \times \left(1 - \frac{\eta_{dist,heating,baseline}}{\eta_{dist,heating,ee}}\right)\right) \times (1 - TRF_{heating}) \end{array} \right]$$

For Electric Furnaces

$$\Delta kWh = \frac{L_{duct,uncond}}{L_{duct}} \times kW_{in} \times EFLH_{heating} \times \left(1 - \frac{\eta_{dist,heating,baseline}}{\eta_{dist,heating,ee}}\right) \times (1 - TRF_{heating})$$

Peak Coincident Demand Savings

For AC and HP Units

$$\Delta kW = \frac{L_{duct,uncond}}{L_{duct}} \times tons \times \frac{12}{EER} \times \left(1 - \frac{\eta_{dist,cooling,baseline}}{\eta_{dist,cooling,ee}}\right) \times (1 - TRF_{cooling}) \times CF$$

Annual Gas Energy Savings

For Gas Furnaces with Capacity < 225,000 BTUh

$$\Delta therms = \frac{L_{duct,uncond}}{L_{duct}} \times \frac{kBTUh_{in}}{100} \times EFLH_{heating} \times \left(1 - \frac{\eta_{dist,heating,baseline}}{\eta_{dist,heating,ee}}\right) \times (1 - TRF_{heating})$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherm	= Annual gas energy savings
tons	= Output cooling capacity in tons (at AHRI standard rating conditions)
$kBTUh_{out}$	= Output heating capacity in kBTUh (at AHRI standard high-temperature rating conditions)
kW_{in}	= Input heating capacity in kW
$kBTUh_{in}$	= Input heating capacity in kBTUh (at AHRI standard high-temperature rating conditions)
$L_{duct,uncond}$	= Length of ductwork in each unconditioned space
L_{duct}	= Total length of ductwork
TRF	= Thermal Regain Factor
SEER	= Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling in BTU, divided by the total electric energy input during the same period in watt-hours
IEER	= Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions
EER	= Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTUhr divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
HSPF	= Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
EFLH	= Equivalent full-load hours
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
η_{dist}	= Distribution system efficiency
CF	= Coincidence factor
12	= kBTUh/ton of air conditioning capacity

3.412 = Conversion factor, one watt-hour equals 3.412 BTU
100 = Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application.
$kBTUh_{out}$		From application.
kW_{in}		From application.
$kBTUh_{in}$		From application.
$L_{duct, uncond}$		From application.
L_{duct}		From application.
$TRF_{cooling}$		See table in the Thermal Regain Factor section below.
$TRF_{heating}$		See table in the Thermal Regain Factor section below.
SEER		Actual equipment nameplate SEER.
IEER		Actual equipment nameplate IEER.
EER		Actual equipment nameplate EER.
HSPF		Actual equipment nameplate HSPF.
COP		Actual equipment nameplate COP.
$EFLH_{heating}$		Look up based on building type, vintage and location from Appendix G.
$EFLH_{cooling}$		Look up based on building type, vintage and location from Appendix G.
$\eta_{dist,cooling,baseline}$		Look up in Appendix H for uninsulated duct system based on building type, location and duct leakage in cooling mode.
$\eta_{dist,heating,baseline}$		Look up in Appendix H for uninsulated duct system based on building type, location and duct leakage in heating mode.
$\eta_{dist,cooling,ee}$		Look up in Appendix H for R-6 insulated duct system based on building type, location and duct leakage in cooling mode.
$\eta_{dist,heating,ee}$		Look up in Appendix H for R-6 insulated duct system based on building type, location and duct leakage in cooling mode.

Thermal Regain Factor[1]

Some energy loss from poorly sealed and insulated ducts can be regained through conduction back into conditioned spaces. The table below lists default thermal regain factors depending on the location of the ductwork. Ductwork in garages, crawl spaces and under slab should be treated as Unconditioned Basement for Appendix H lookup.

[1] Home Energy Saver & Score: Engineering Documentation, Thermal Distribution Efficiency

Duct Location	$TRF_{cooling}$	$TRF_{heating}$
Attic	0.1	0.1
Garage	0.1	0.1
Crawl space, unvented, uninsulated	0.6	0.6
Crawl Space, Unvented, Insulated Building Floor and Crawl Space walls	0.6	0.3
Crawl Space, Unvented, Insulated Floor Only	0.3	0.3
Crawl Space, Vented, Uninsulated	0.6	0.55
Crawl Space, Insulated Building Floor and Crawl Space Walls	0.63	0.6
Crawl Space, Vented, Insulated Floor Only	0.3	0.3
Basement, Uninsulated	0.5	0.5
Basement, Insulated Walls	0.6	0.6
Under-slab	0.2	0.2

For duct systems in multiple unconditioned spaces, evaluate the ductwork in each space separately and sum together to calculate the total energy savings. For each equation, use the length of the insulated ductwork in each specific unconditioned space.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.69.[2]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a ducted HVAC system with insufficient sealing and insulation that has undergone duct-blaster testing. Look up baseline uninsulated distribution system efficiency from Appendix H based on building type, location and duct total leakage.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a sealed and insulated duct system in a retrofit application that has undergone post-implementation duct-blaster testing. Supply and return ducts shall be insulated to a minimum of R-8 where 3 inches in diameter or greater and R-6 where less than 3 inches in diameter. Total leakage shall be less than or equal to 4 cubic feet per minute per 100 square feet of conditioned floor area.[3]

Look up compliance distribution system efficiency from Appendix H based on building type, location and duct total leakage from duct blaster test. Models for HVAC distribution efficiency with R-8 insulation are currently under development; values associated with R-6 shall be used until R-8 data is available.

---

[2] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by the Mid-Atlantic TRM Version 7.0 published May 2017 and by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the TRM Management Committee.
[3] ECCCNYS 2016 & NYCECC 2016, R403.3.1 & R403.3.4.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. Home Energy Saver & Score: Engineering Documentation, Thermal Distribution Efficiency
   Available from: http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/heating-and-cooling-calculation/thermal-distribution-efficiency/thermal-distribution-efficiency
3. ECCCNYS 2016, per IECC 2015; R403.3.1: Insulation (Prescriptive) & R403.3.4: Duct Leakage (Prescriptive)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency
4. NYCECC 2016; R403.3.1: Insulation (Prescriptive) & R403.3.4: Duct Leakage (Prescriptive)
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-5	6/26/2018

Return to Table of Contents

HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

OUTDOOR TEMPERATURE SETBACK CONTROL FOR HYDRONIC BOILER

Measure Description

This measure covers the installation of outdoor temperature setback control for single and multi-family residential gas boilers. Outdoor air reset control adjusts the hot water set point temperature of the boiler in response to outdoor air temperature. This measure is only applicable to retrofit of existing boiler systems. One outdoor temperature setback measure may be applied to each boiler.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{in}$		From application.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
ESF	0.05[1]	

[1] Cadmus Group, Inc., Home Energy Services Impact Evaluation, August 2012, pg. 20

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing single or multi-family residential boiler without outdoor temperature setback control.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an existing single or multi-family residential boiler equipped with outdoor temperature setback control.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N / A

Ancillary Electric Savings Impacts

Lower boiler set point temperatures may cause hot water circulators to run longer cycles. This impact is anticipated to be minor and is not quantified in this measure.

References

1. Cadmus Group, Inc., Home Energy Services Impact Evaluation, August 2012 Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Home-Energy-Services-Impact-Evaluation-Report_Part-of-the-Massachusetts-2011-Residential-Retrofit-and-Low-Income-Program-Area-Evaluation.pdf

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-16-4	6/30/2016
6-18-6	6/26/2018

Return to Table of Contents

VENDING MACHINE AND NOVELTY COOLER CONTROL

Measure Description

This measure covers the installation of time clocks and occupancy sensors on vending machines and novelty coolers to ensure units maintain desired product temperatures when required. The time clock control mechanism is a programmed-schedule time clock that is assumed to be set to turn the equipment off coincident with the facility closing time and turn equipment on one hour before opening time to allow the products to return to the desired sale temperature.

The occupancy sensor control mechanism uses an infrared sensor to turn off the vending machine when the surrounding area is unoccupied. The device also monitors the ambient temperature and powers up the machine as required to keep products cool. Additionally, the sensor monitors the electrical current used by the machine to ensure it is not turned off during a compressor cycle to prevent a high head pressure start from occurring.

This measure is only applicable to vending machines without a low power mode. A low power mode is a state in which a vending machine's lighting, refrigeration, and/or other energy using systems are automatically adjusted (without user intervention) such that they consume less energy than they consume in an active vending environment.[1] This measure is only applicable to vending machines and novelty coolers containing non-perishable products.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kW/unit) \times hrs_{off} \times Cycle$$

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
units	= Number of measures installed under the program
(kW/unit)	= Vending machine power (kW), based on nameplate Volts, Amps, Phase and Power Factor
hrs_{off}	= Unit off hours per year
Cycle	= Compressor duty cycle

[1] 10 CFR 431 Subpart Q, Appendix B 1.2 Definitions

Summary of Variables and Data Sources

Variable	Value	Notes
(kW/unit)	$= Volts \times Amps \times \sqrt{Phase} \times PF$	Based on nameplate Volts, Amps, Phase and Power Factor. If power factor is unknown, use a default value of 0.55.[2]
hrs_{off}	Time clock: From application Occupancy Sensor: 2,891	Based on control type. For time clocks, off hours are equivalent to annual facility closed hours minus facility operating days. If unknown, look up in Operating Hours section below based on facility type.
Cycle	0.45	Compressor average duty cycle. [3]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Incentives are Calculated

The baseline condition is a vending machine or novelty cooler containing non-perishable products without time clock or occupancy IR sensing/load sensing control.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a vending machine or novelty cooler containing non-perishable products with time clock or occupancy IR sensing/load sensing control installed.

Operating Hours

Novelty coolers and refrigerated vending machines are assumed to be connected 24 hours per day, 365 days per year. In the baseline case, these units operate during all hours and cycle according to the duty cycle cited above.

With time clock control, units are automatically shut off when the facility closes and turned back on one hour prior to the facility opening to allow the system to return the contents to their desired temperature. Energy savings are calculated based on the system off hours due to installed time clock control. If unknown, use the default off hours based on building type from the table below. This table was developed by subtracting the default lighting hours in the C&I Interior Lamps and Fixtures measure in this TRM from 8,760, and subtracting 365 from the result (assumes 365 days of facility operation). Facilities expected to operate 24/7 are excluded.

[2] Analysis of Cooler Control Energy Conservation Measures: Final Report, Select Energy Services, Inc., March 2004
[3] Ibid

Facility Type	hrs_{off} (hrs/yr)	Facility Type	hrs_{off} (hrs/yr)
Auto Related[a]	5,585	Manufacturing Facility	5,538
Bakery	5,541	Medical Offices	4,647
Banks	4,647	Motion Picture Theatre	6,441
Church	6,440	Museum	4,647
College– Cafeteria[b]	5,682	Nursing Homes	2,555
College – Classes	5,809	Office (General Office Types)[b]	5,382
College - Dormitory	5,329	Parking Garages	4,027
Commercial Condos[c]	5,295	Parking Lots	4,295
Convenience Stores	2,019	Penitentiary	2,918
Convention Center	6,441	Performing Arts Theatre	5,809
Court House	4,647	Post Office	4,647
Dining: Bar Lounge/Leisure	4,213	Pump Stations	6,446
Dining: Cafeteria / Fast Food	1,939	Refrigerated Warehouse	5,793
Dining: Family	4,213	Religious Building	6,440
Entertainment	6,443	Restaurants	4,213
Exercise Center	2,559	Retail	4,932
Fast Food Restaurants	2,019	School / University	6,208
Fire Station (Unmanned)	6,442	Schools (Jr./Sr. High)	6,208
Food Stores	4,340	Schools (Preschool/Elementary)	6,208
Gymnasium	5,809	Schools (Technical/Vocational)	6,208
Industrial - 1 Shift	5,538	Small Services	4,645
Industrial - 2 Shift	3,665	Sports Arena	6,441
Industrial - 3 Shift	1,764	Town Hall	4,647
Laundromats	4,339	Transportation	1,939
Library	4,647	Warehouse (Not Refrigerated)	5,793
Light Manufacturers[b]	5,782	Waste Water Treatment Plant	1,764
Lodging (Hotels/Motels)	5,331	Workshop	4,645
Mall Concourse	3,562		

[a] New car showrooms and Big Box retail stores with evening and/or weekend hours should use the Facility Type "Retail" for vending machine and novelty cooler off hours
[b] Lighting operating hours data from the 2008 California DEER Update study
[c] Lighting operating hours data for offices used

Annual occupancy sensor control hours are assumed to be 2,891 based on 33% energy savings of vending machine or novelty with installed device.[4]

Effective Useful Life (EUL)

See Appendix P.

[4] Analysis of NREL Cold-Drink Vending Machines for Energy Savings, June 2003.

Ancillary Fossil Fuel Savings Impacts

Reduced refrigeration system run hours during facility operation will result in a slight increase in space heating requirements and a slight decrease in space cooling requirements. These effects are not considered in the prescribed savings methodology.

Ancillary Electric Savings Impacts

Reduced refrigeration system run hours during facility operation will result in a slight increase in space heating requirements and a slight decrease in space cooling requirements. These effects are not considered in the prescribed savings methodology.

References

1. 10 CFR 431 Subpart Q, Appendix B, 1.2 Definitions
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=bffd54323b0e3f933976ce4b4ad86e55&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1296.b
2. Analysis of Cooler Control Energy Conservation Measures: Final Report, Select Energy Services, Inc., March 2004
   Available from: https://forum.cee1.org/system/files/library/1220/392.pdf
3. Analysis of NREL Cold-Drink Vending Machines for Energy Savings, NREL, June 2003
   Available from: https://www.researchgate.net/profile/Michael_Deru/publication/242168498_Analysis_of_NREL_Cold-Drink_Vending_Machines_for_Energy_Savings/links/54bd240d0cf218da939190ab/Analysis-of-NREL-Cold-Drink-Vending-Machines-for-Energy-Savings.pdf?origin=publication_detail

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-7	6/26/2018

Return to Table of Contents

AIR DRYER - REFRIGERATED

Measure Description

This measure covers the installation of a cycling or variable frequency drive (VFD)-controlled refrigerated air dryer on a compressed air system with a non-cycling air dryer. High efficiency air dryers utilize a refrigeration system to condense and remove moisture from a compressed air system. As demand requires, cycling refrigerated air dryer systems cool a medium that cools the compressed air. VFD-controlled refrigerated air dryer systems use a variable speed drive as required by the demand. Both systems save energy by dismissing the need for the system to run continuously at full speed.

This measure is applicable to single compressor systems only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times CFM_{dryer} \times (\Delta kW/CFM) \times hrs$$

Peak Coincident Demand Savings

$$\Delta kW = units \times CFM_{dryer} \times (\Delta kW/CFM) \times F_{peak} \times CF$$

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
units = Number of measures installed under the program
CFM_{dryer} = Full flow rated capacity of refrigerated air dryer, in cubic feet per minute
ΔkW/CFM = kW reduction per full flow rated CFM
hrs = Annual operating hours of dryer
F_{peak} = Peak operation factor; binary variable to indicate whether equipment operates during electric system peak (summer weekday hour ending at 5PM)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
CFM_{dryer}		From application.
ΔkW/CFM	0.00554[1]	

[1] Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV GL, October 2015, Table 1-10: Dryer kW per CFM Saved

Variable	Value	Notes
hrs		From application.
F_{peak}	Peak Operation: 1 No Peak Operation: 0	From application.
CF	0.8	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.[2]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a compressed air system equipped with a non-cycling air dryer.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a compressed air system with a cycling or VFD-controlled refrigerated air dryer.

Operating Hours

Hours of operation shall be taken from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV-GL, prepared by KEMA, Inc. for Massachusetts Energy Efficiency Advisory Council, October 2015
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

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

Record of Revision

Record of Revision Number	**Issue Date**
1	10/15/2010
6-18-8	6/26/2018

Return to Table of Contents

FAUCET – LOW-FLOW AERATOR

Measure Description

This measure covers the installation of low-flow faucet aerators in commercial and industrial applications. A faucet aerator is a water saving device that attaches to a preinstalled faucet and reduces water flow while maintaining appropriate water pressure. Retrofitting existing code compliant aerators in locations where service water is supplied by electric or natural gas fired hot water heaters with more energy efficient aerators reduces hot water consumption resulting in corresponding energy savings. This measure is not applicable to public lavatories.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{\left(GPM_{baseline} \times Flow_{r,baseline} - GPM_{ee} \times Flow_{r,ee}\right) \times \Delta T_{main} \times 8.33}{3{,}412} \times 60 \times hrs \times days \times \frac{1}{E_{t,elec}}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therm = units \times \frac{\left(GPM_{baseline} \times Flow_{r,baseline} - GPM_{ee} \times Flow_{r,ee}\right) \times \Delta T_{main} \times 8.33}{100{,}000} \times 60 \times hrs \times days \times \frac{1}{E_{t,gas}}$$

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
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
GPM	= Gallons per minute
$Flow_r$	= Flow rate restricted
ΔT_{main}	= Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F)
hrs	= Operating hours per day
days	= Operating days per year
E_t	= Water heater thermal efficiency
8.33	= Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
60	= Conversion factor, minutes in one hour

3,412 = Conversion factor, one kWh equals 3,412.14 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$	Kitchen Sink: 2.2 Private Lavatory: 1.5	Maximum flow rate defined by NYS[1] and NYC[2] plumbing code. For municipalities subject to EPA WaterSense (i.e., WaterSense Partners), maximum standard flow rate under that program supersede federal standard values.
GPM_{ee}		From application, or use minimum program compliant flowrate if unknown.
$Flow_{r,baseline}$	0.83[3]	
$Flow_{r,ee}$	0.95[4]	
hrs	0.25	Based on an assumed 30 uses per day, 30 seconds per use.[5]
days		Facility annual operating days, from application or look up based on facility type in Operating Hours section below.
ΔT_{main}	$T_{faucet} - T_{main}$	Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F).
T_{faucet}	Lavatory: 86 Kitchen: 93 Unknown: 88[6]	Faucet operating temperature (°F).[7]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
$E_{t,elec}$	0.98	Thermal efficiency of electric water heater.[8]
$E_{t,gas}$	0.80	Thermal efficiency of gas water heater. [9]

[1] 2017 NYS Uniform Code Supplement, Table P2903.2
[2] 2014 NYC Plumbing Code, Table 604.4
[3] Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008, pg. 1-265
[4] Ibid.
[5] FEMP, Domestic Water Conservation Technologies, pg. 35
[6] Calculated weighted average based on statewide average assumptions ((1*93)+(3*86))/(1+3) = 88
[7] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, Directed to Michigan Evaluation Working Group. Table 93 “HEI Updated PY2014 Variable Assumptions”
[8] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*
[9] Per 10 CFR 431.110 (a)

Cold Water Inlet Temperature (T_{main})

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

City	Annual average outdoor temperature[11] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor

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

Baseline Efficiency from Which Savings are Calculated

The baseline condition is a kitchen sink or private lavatory faucet aerator as defined in the Measure Description section above with flow rate equivalent to maximum code compliant GPM per application.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a low-flow kitchen sink or private lavatory faucet aerator as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

Faucets are assumed to be used 30 times per day with an average of 30 seconds per use.[12] Days of operation shall be taken from application. If unknown, default operating days per year are provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[13]

Facility Type	Days/Year
Community College	283
Fast Food	363

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

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

[12] FEMP, Domestic Water Conservation Technologies, pg. 35

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

Facility Type	Days/Year
Full Service Restaurant	321
Grocery	365
Hospital	365
Hotel	365
Miscellaneous	325
Motel	365
Primary School	180
Secondary School	180
Small Office	250
University	283

Effective Useful Life

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from: http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Energy-related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008
   Available from: http://www.seattle.gov/light/conserve/reports/paper_10.pdf
4. Federal Energy Management Program, Domestic Water Conservation Technologies, October 2002
   Available from: https://www1.eere.energy.gov/femp/pdfs/22799.pdf
5. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, Directed to Michigan Evaluation Working Group
   Available from: http://www.oracle.com/us/industries/utilities/cadmus-indianapolis-power-light-3697534.pdf

6. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters
Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
7. 10 CFR 431.110 Energy conservation standards and their effective dates
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=64f994924a5f31b841cab23a6d543f85&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1110
8. Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
Available from:
https://energy.mo.gov/sites/energy/files/algorithmformainswatertemperature.pdf
9. NOAA National Centers for Environmental Information – NCDC 1981-2010 Climate Normals
Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
10. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014.
Available from: http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

Record of Revision

Record of Revision Number	**Issue Date**
1	10/15/2010
6-18-9	6/26/2018

Return to Table of Contents

HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

REFRIGERANT CHARGE CORRECTION & TUNE UP – CAC AND ASHP

Measure Description

This measure estimates savings associated with refrigerant charge correction of air-cooled central air conditioners and air source heat pumps in small commercial applications. In order to be eligible for savings claims, the scope of work performed must include manufacturer recommended AC tune-up procedures including but not limited to the cleaning of condenser coils.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For Units with Cooling Capacity < 65,000 BTU/h

$$\Delta kWh = units \times \left[\begin{array}{c} \left(tons/unit \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}} \right) \times EFLH_{cooling} \right) \\ + \\ \left(kBTUh_{out}/unit \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}} \right) \times EFLH_{heating} \right) \end{array} \right]$$

For Units with Cooling Capacity ≥ 65,000 BTU/h

$$\Delta kWh = units \times \left[\begin{array}{c} \left(tons/unit \times \left(\frac{12}{IEER_{baseline}} - \frac{12}{IEER_{ee}} \right) \times EFLH_{cooling} \right) \\ + \\ \left(\frac{kBTUh_{out}/unit}{3{,}412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}} \right) \times EFLH_{heating} \right) \end{array} \right]$$

Peak Coincident Demand Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}} \right) \times CF$$

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
units	= Number of measures installed under the program

tons/unit	= Tons of air conditioning per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)
$kBTUh_{out}/unit$	= Output heating capacity in kBTUh (at AHRI standard high-temperature rating conditions)
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
IEER	= Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions (used only for units with cooing capacity ≥ 65,000 BTU/h)
EER	= Energy efficiency ratio under peak conditions, measurement of cooling capacity for a unit (in Btu/hour) / electrical energy used (watts) (at AHRI standard rating conditions)
HSPF	= Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$EFLH_{cooling}$	= Equivalent full-load cooling hours
$EFLH_{heating}$	= Equivalent full-load heating hours
CF	= Coincidence factor
12	= kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application
$SEER_{ee}$		Actual equipment nameplate SEER.
$SEER_{baseline}$		Actual equipment nameplate SEER, derated in accordance with the Baseline Degradation Factor section below.
$IEER_{ee}$		Actual equipment nameplate IEER.
$IEER_{baseline}$		Actual equipment nameplate IEER, derated in accordance with the Baseline Degradation Factor section below.
EER_{ee}		Actual equipment nameplate EER
$EER_{baseline}$		Actual equipment nameplate EER, derated in accordance with the Baseline Degradation Factor section below.
$HSPF_{ee}$		Actual equipment nameplate HSPF.
$HSPF_{baseline}$		Actual equipment nameplate HSPF, derated in accordance with the Baseline Degradation Factor section below.
COP_{ee}		Actual equipment nameplate COP.
$COP_{baseline}$		Actual equipment nameplate COP, derated in accordance with the Baseline Degradation Factor section below.
$EFLH_{cooling}$		From application. If unknown, look up based on building type, system type and location from Appendix G.

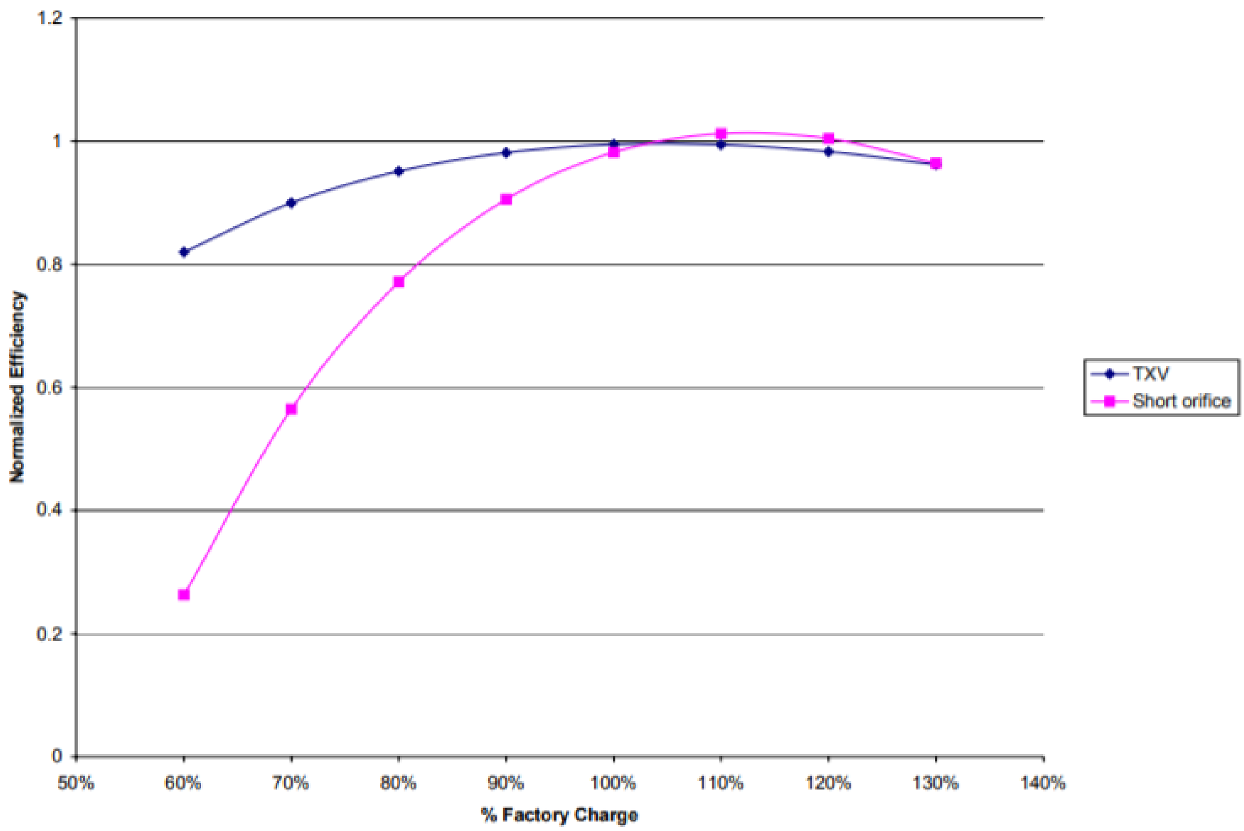
Variable	Value	Notes
$EFLH_{heating}$		From application. If unknown, look up based on building type, system type and location from Appendix G.
CF	0.8	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.[1]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is equivalent to the existing condition with efficiency ratings taken from the equipment nameplate, derated to account for under or overcharging. The efficiency improvement resulting from refrigerant charge adjustment is dependent upon the discrepancy between the actual equipment charge before the adjustment was performed and the manufacturer's specification. The efficiency adjustment factor as a function of charge adjustment is taken from the figure or table below.[2] Note the efficiency change depends on the type of expansion valve. Use the curve or column labeled "TXV" for units with thermal expansion valves; otherwise use the curve or column labeled "Short orifice".



[1] *No source specified – update pending availability and review of applicable references.*
[2] Efficiency as a function of charge adjustment from Small HVAC System Design Guide, New Buildings Institute, 2003, pg 40

% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)	% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)
60%	0.26	0.82	96%	0.96	0.99
62%	0.32	0.84	98%	0.97	0.99
64%	0.39	0.85	100%	0.98	1.00
66%	0.45	0.87	102%	0.99	1.00
68%	0.51	0.89	104%	1.00	1.00
70%	0.56	0.90	106%	1.00	1.00
72%	0.61	0.91	108%	1.00	1.00
74%	0.66	0.92	110%	1.00	1.00
76%	0.70	0.93	112%	1.00	0.99
78%	0.73	0.94	114%	1.00	0.99
80%	0.77	0.95	116%	1.00	0.99
82%	0.80	0.96	118%	1.00	0.99
84%	0.83	0.97	120%	1.00	0.99
86%	0.86	0.97	122%	1.00	0.98
88%	0.88	0.98	124%	0.99	0.98
90%	0.91	0.98	126%	0.98	0.97
92%	0.92	0.99	128%	0.97	0.97
94%	0.94	0.99	130%	0.96	0.96

If the equipment contains multiple refrigeration circuits, relevant baseline efficiency ratings shall be calculated by establishing the total degradation factor as the sum of each circuit's derating factor multiplied by its percentage of the total system capacity and multiplying this value by the system's nameplate efficiency. The equation for $EER_{baseline}$, for example, is shown below:

$$EER_{baseline} = EER_{ee} \times \sum_{n} (\%Cap_n \times Fderate_n)$$

where:

n = Each circuit
%Cap = Percentage capacity of total system capacity
Fderate = Baseline degradation factor, based on % over/undercharging from table above

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a commercial air conditioner or heat pump with corrected refrigerant charge. SEER, IEER, EER, HSPF, and COP are taken from application as reported by equipment manual.

Operating Hours

Equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type, system type and location can be found in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Small HVAC System Design Guide, New Buildings Institute, White Salmon, WA for the California Energy Commission.
   Available from: http://www.energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-12.PDF

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-10	6/26/2018

Return to Table of Contents

MOTORS AND DRIVES

MOTOR REPLACEMENT

Measure Description

This measure covers the installation of high efficiency, three-phase electric HVAC fan or pump motors of 200 hp or less in commercial and industrial applications.[1] Full-load efficiency of installed equipment must exceed current code requirements as defined in the Baseline Efficiency section below to qualify. Claimed savings are based on increased operating efficiency.

Efficient motors generally run at slightly higher RPM than standard motors. Unless the motor drive system is modified to correct for higher RPM operation, the power delivered by the motor may increase. This increase in power delivery may negate the effects of improved efficiency. Therefore, when replacing a standard-efficiency motor, a high-efficiency motor with lower or equal full-load speed must be selected to prevent any negation of predicted energy savings resulting from a higher efficiency. To provide the correct flow, it may be necessary to adjust fan sheaves or pump-impeller diameters.[2]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hp \times RLF \times 0.746\ (kW/hp) \times \left[\left(\frac{1}{\eta_{baseline}}\right) - \left(\frac{1}{\eta_{ee}}\right)\right] \times FLH$$

Peak Coincident Demand Savings

$$\Delta kW = units \times hp \times RLF \times 0.746\ (kW/hp) \times \left[\left(\frac{1}{\eta_{baseline}}\right) - \left(\frac{1}{\eta_{ee}}\right)\right] \times CF$$

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
units	= Number of measures installed under the program
hp	= Horsepower
RLF	= Rated load factor
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
η	= Energy efficiency (0 -100%)

[1] Partners Listing of NEMA Premium Compliant Electric Motors (accessed 3/19/2018)
[2] Energy Innovators Initiative, Office of Energy Efficiency, Natural Resources Canada, Premium-Efficiency Motors

FLH = Full-load hours
CF = Coincidence factor
0.746 = Conversion factor (kW/hp), 746 watts equals one horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		Rated horsepower of the proposed equipment, from application.
$\eta_{baseline}$		Full-load efficiency of the baseline motor. Look up from Appendix L based on proposed motor type (open or enclosed), number of poles (2, 4 or 6) and horsepower.
η_{ee}		Full-load efficiency of the proposed motor, from application.
RLF		Ratio of the peak annual motor load to the maximum connected load (RLF = hp_{peak}/hp_{max}), from application. If unknown, assume 0.75.[3]
FLH		Full-load hours in the energy efficient case, from application. If unknown, look up based on facility type and motor application in the Operating Hours section below.
CF	0.8	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.[4]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a three-phase electric HVAC fan or pump motor of equivalent type, speed and horsepower to the proposed case with minimally code compliant full-load efficiency per Appendix L, established by ECCCNYS[5] and NYCECC,[6] in accordance with federal energy conservation standards.[7]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a three-phase electric HVAC fan or pump motor with a speed at or below that of the baseline motor and full-load efficiency exceeding the baseline NEMA premium full-load efficiency established per the Baseline Efficiencies section above. Additional compliance requirements shall be set by program eligibility criteria.

---

[3] U.S. DOE, Determining Electric Motor Load and Efficiency, p. 1; assumes system is designed to maximize efficiency.
[4] *No source specified – update pending availability and review of applicable references.*
[5] ECCCNYS 2016, Table C405.8(1)
[6] NYCECC 2016, Table C405.8(1)
[7] 10 CFR 431.25(h) Table 5

Operating Hours

Motor full-load hours are defined as the total annual energy consumption divided by the peak hourly demand.

$$FLH = \frac{kWh}{kW_{max}}$$

For loads that do not vary with time (i.e., a motor driving a constant load), full-load hours are equal to the operating hours.

If full-load hours are unknown, use default values based on the application and building type from the table below.[8]

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Auto Related	4,056	1,878	5,376
Bakery	2,854	1,445	5,376
Banks, Financial Centers	3,748	1,767	5,376
Church	1,955	1,121	5,376
College - Cafeteria	6,376	2,713	5,376
College - Classes/Administrative	2,586	1,348	5,376
College - Dormitory	3,066	1,521	5,376
Commercial Condos	4,055	1,877	5,376
Convenience Stores	6,376	2,713	5,376
Convention Center	1,954	1,121	5,376
Court House	3,748	1,767	5,376
Dining: Bar Lounge/Leisure	4,182	1,923	5,376
Dining: Cafeteria / Fast Food	6,456	2,742	5,376
Dining: Family	4,182	1,923	5,376
Entertainment	1,952	1,120	5,376
Exercise Center	5,836	2,518	5,376
Fast Food Restaurants	6,376	2,713	5,376
Fire Station (Unmanned)	1,953	1,121	5,376
Food Stores	4,055	1,877	5,376
Gymnasium	2,586	1,348	5,376
Hospitals	7,674	3,180	5,376
Hospitals / Health Care	7,666	3,177	5,376
Industrial - 1 Shift	2,857	1,446	5,376
Industrial - 2 Shift	4,730	2,120	5,376
Industrial - 3 Shift	6,631	2,805	5,376
Laundromats	4,056	1,878	5,376
Library	3,748	1,767	5,376

[8] Connecticut Program Savings Document, 12th Edition for 2017 Program Year, UIL Holdings Corporation and Eversource Energy, October 2016. Appendix 5, Hours of Use

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Light Manufacturers	2,857	1,446	5,376
Lodging (Hotels/Motels)	3,064	1,521	5,376
Mall Concourse	4,833	2,157	5,376
Manufacturing Facility	2,857	1,446	5,376
Medical Offices	3,748	1,767	5,376
Motion Picture Theatre	1,954	1,121	5,376
Multi-Family (Common Areas)	7,665	3,177	5,376
Museum	3,748	1,767	5,376
Nursing Homes	5,840	2,520	5,376
Office (General Office Types)	3,748	1,767	5,376
Office/Retail	3,748	1,767	5,376
Parking Garages & Lots	4,368	1,990	5,376
Penitentiary	5,477	2,389	5,376
Performing Arts Theatre	2,586	1,348	5,376
Police / Fire Stations (24 Hr)	7,665	3,177	5,376
Post Office	3,748	1,767	5,376
Pump Stations	1,949	1,119	5,376
Refrigerated Warehouse	2,602	1,354	5,376
Religious Building	1,955	1,121	5,376
Residential (Except Nursing Homes)	3,066	1,521	5,376
Restaurants	4,182	1,923	5,376
Retail	4,057	1,878	5,376
School / University	2,187	1,205	5,376
Small Services	3,750	1,768	5,376
Sports Arena	1,954	1,121	5,376
Town Hall	3,748	1,767	5,376
Transportation	6,456	2,742	5,376
Warehouse (Not Refrigerated)	2,602	1,354	5,376
Waste Water Treatment Plant	6,631	2,805	5,376
Workshop	3,750	1,768	5,376

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

High efficiency motors reject less heat into the conditioned space increasing space heating requirements while decreasing cooling load. These impacts are not considered in the prescribed formulation of savings.

Ancillary Electric Savings Impacts

High efficiency motors reject less heat into the conditioned space increasing space heating requirements while decreasing cooling load. These impacts are not considered in the prescribed formulation of savings.

References

1. Partners Listing of NEMA Premium Compliant Electric Motors
   Available from: https://www.nema.org/Policy/Energy/Efficiency/Documents/Nema_Premium_Partners.pdf
2. Energy Innovators Initiative, Office of Energy Efficiency, Natural Resources Canada, Premium-Efficiency Motors
   Available from: https://www.prismengineering.com/sites/default/files/upload/fact-sheets/Prism-Fact-sheet-Premium-efficiency-motors.pdf
3. U.S. DOE, Determining Electric Motor Load and Efficiency
   Available from: https://energy.gov/sites/prod/files/2014/04/f15/10097517.pdf
4. ECCCNYS 2016, per IECC 2015; Table C405.8(1): Minimum Nominal Full-Load Efficiency For 60 HZ NEMA General Purpose Electric Motors (Subtype I) Rated 600 Volts or Less
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
5. NYCECC 2016, per IECC 2015; Table C405.8(1): Minimum Nominal Full-Load Efficiency For 60 HZ NEMA General Purpose Electric Motors (Subtype I) Rated 600 Volts or Less
   Available from: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
6. 10 CFR 431.25 (h) Table 5: Nominal Full-Load Efficiencies of NEMA Design A, NEMA Design B and IEC Design N Motors (Excluding Fire Pump Electric Motors) at 60Hz
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=5423daf354376cde95da84156e424cc8&mc=true&node=pt10.3.431&rgn=div5#sp10.3.431.b
7. Connecticut Program Savings Document, 12th Edition for 2017 Program Year, UIL Holdings Corporation and Eversource Energy, October 2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-12	6/26/2018

Return to Table of Contents

BLOWER FAN – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR FOR HVAC DISTRIBUTION

Measure Description

This measure covers the replacement of a HVAC circulation (blower) fan motor with an electronically commutated motor (EC motor) in a commercial building. The baseline condition for this measure is assumed to be a single-speed, permanent-split capacitor (PSC) motor. EC motors provide increased efficiency over PSC motors by controlling speed and torque, providing both efficiency and reliability.

This measure addresses the specific application of EC motors rated to one horsepower (HP) or less in a replacement scenario of a direct-drive circulation fan motor in an HVAC air distribution system. This measure is not applicable to exhaust fan motors.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{heating} + \Delta kWh_{cooling}$$

$$\Delta kWh_{cooling} = \frac{(W_{baseline} \times ESF_{cooling})}{1{,}000} \times LF \times hrs \times (1 + HVAC_c)$$

$$\Delta kWh_{heating} = \frac{(W_{baseline} \times ESF_{heating})}{1{,}000} \times LF \times hrs \times (1 - HVAC_c)$$

Peak Coincident Demand Savings

$$\Delta kW = \frac{(W_{baseline} \times ESF_{cooling})}{1{,}000} \times LF \times (1 + HVAC_d) \times CF$$

Annual Gas Savings

$$\Delta therms = \frac{(W_{baseline} \times ESF_{heating})}{1{,}000} \times LF \times hrs \times HVAC_g$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
$\Delta kWh_{cooling}$ = Annual electric energy savings during the cooling season
$\Delta kWh_{heating}$ = Annual electric energy savings during the heating season
$W_{baseline}$ = Baseline PSC motor wattage
ESF = Energy savings factor
LF = Motor load factor
hrs = Operating hours

$HVAC_c$ = 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
CF = Coincidence factor
1,000 = Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
$W_{baseline}$		From application.
$ESF_{heating}$	0.23[1]	
$ESF_{cooling}$	0.38[2]	
LF	0.9[3]	
hrs		From application, if unknown, see operating hours section below.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$		HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_g$		HVAC interaction factor for annual natural gas consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	0.8	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.[4]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard efficiency, single-speed PSC motor in a direct-drive HVAC circulation (blower) fan application. Baseline wattage shall be derived from the nameplate rating of the existing motor.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an EC motor as described in the Measure Description section above in a direct-drive HVAC circulation (blower) fan application.

[1] US DOE, Evaluation of Retrofit Variable-Speed Furnace Fan Motors, January 2014, Section 4: Discussion, pg 23
[2] Ibid
[3] *No source specified – assumed value to reflect that motors do not typically run at 100% of rated power.*
[4] *No source specified – update pending availability and review of applicable references.*

Operating Hours

Operating hours shall be taken from application. If the operating hours are unknown and the circulation fan operates on the same schedule as the HVAC system, look up operating hours from Appendix G. If the operating hours are unknown and the circulation fan operates on the same schedule as the facility, look up hours by building type from the table below.

Facility Type	Hours (hrs/yr)	Facility Type	Hours (hrs/yr)
Auto Related[a]	2,810	Manufacturing Facility	2,857
Automotive / Transportation Service or Repair Facility (24/7)	8,760	Medical Offices	3,748
Bakery	2,854	Motion Picture Theatre	1,954
Banks	3,748	Multi-Family (Common Areas)	7,665
Church	1,955	Museum	3,748
College– Cafeteria[b]	2,713	Nursing Homes	5,840
College – Classes	2,586	Office (General Office Types)[b]	3,013
College - Dormitory	3,066	Parking Garages	4,368
Commercial Condos[c]	3,100	Parking Garages (24/7)	7,717
Convenience Stores	6,376	Parking Lots	4,100
Convention Center	1,954	Penitentiary	5,477
Court House	3,748	Performing Arts Theatre	2,586
Dining: Bar Lounge/Leisure	4,182	Police / Fire Stations (24 Hr)	7,665
Dining: Cafeteria / Fast Food	6,456	Post Office	3,748
Dining: Family	4,182	Pump Stations	1,949
Entertainment	1,952	Refrigerated Warehouse	2,602
Exercise Center	5,836	Religious Building	1,955
Fast Food Restaurants	6,376	Restaurants	4,182
Fire Station (Unmanned)	1,953	Retail	3,463
Food Stores	4,055	School / University	2,187
Gymnasium	2,586	Schools (Jr./Sr. High)	2,187
Hospitals	7,674	Schools (Preschool/Elementary)	2,187
Hospitals / Health Care	7,666	Schools (Technical/Vocational)	2,187
Industrial - 1 Shift	2,857	Small Services	3,750
Industrial - 2 Shift	4,730	Sports Arena	1,954
Industrial - 3 Shift	6,631	Town Hall	3,748
Laundromats	4,056	Transportation	6,456
Library	3,748	Warehouse (Not Refrigerated)	2,602
Light Manufacturers[b]	2,613	Waste Water Treatment Plant	6,631
Lodging (Hotels/Motels)	3,064	Workshop	3,750
Mall Concourse	4,833		

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

HVAC circulation fan EC motors generate less heat during operation, resulting in decreased cooling loads and increased heating loads. These effects are captured in the prescribed methodology detailed above. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

Ancillary Electric Savings Impacts

HVAC circulation fan EC motors generate less heat during operation, resulting in decreased cooling loads and increased heating loads. These effects are captured in the prescribed methodology detailed above. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

Improved fan impeller design in the efficient case may contribute to additional efficiency gains; these impacts are not considered in the prescribed methodology at this time.

References

1. US DOE, Evaluation of Retrofit Variable-Speed Furnace Fan Motors, R. Aldrich and J. Williamson, Consortium for Advanced Residential Buildings, January 2014
   Available from:
   http://digital.library.unt.edu/ark:/67531/metadc864348/m2/1/high_res_d/1122310.pdf
2. NIDEC Motor Corporation, Residential and Commercial HVACR Standard Motor Catalog, 2015
   Available from: http://acim.nidec.com/motors/usmotors/-/media/usmotors/documents/catalogs/hvacr/hvacr400.ashx?la=en

Record of Revision

Record of Revision Number	Issue Date
1-16-14	12/31/2015
6-18-13	6/26/2018

Return to Table of Contents

FREEZER AND COOLER DOOR GASKETS

Measure Description

This measure covers the replacement of reach-in and walk-in refrigerated display case door gaskets that have become damaged due to normal use and/or the failure of anti-condensate heater elements. When damaged and/or missing, the warmer, more humid air present in the store will infiltrate the case increasing the refrigeration system load while often reducing the efficiency of the evaporator unit as a result of frost accumulation. This measure applies to gaskets on both reach-in doors and the main door of walk-in units typical of supermarkets, convenience stores, and restaurants.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = ft_{door} \times (\Delta kWh/ft)$$

Peak Coincident Electric Demand Savings

$$\Delta kW = \frac{ft_{door} \times (\Delta kWh/ft)}{8{,}760} \times CF$$

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
ft_{door}	= Linear feet of damaged and/or missing door gasket
(ΔkWh/ft)	= Annual electric energy savings per linear foot of damaged and/or missing door gasket
CF	= Coincidence factor
8,760	= Hours per year

Summary of Variables and Data Sources

Variable	Value	Notes
ft_{door}		From application.
(ΔkWh/ft)	Cooler (>32 °F): 15 Freezer (<32 °F): 114	Annual kWh per linear foot of replaced door gasket.[1]
CF	1.0	

Coincidence Factor (CF)

The recommended coincidence factor for this measure is 1.0.[2]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is premised on a door with damaged and/or missing gaskets, assumed to be 50% effective.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the installation of intact door gaskets so as to achieve a minimum 1.5% infiltration rate or lower.

Operating Hours

Refrigeration equipment is assumed to be available for operation 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction of ambient air infiltration into the refrigerated case due to improved gaskets reduces the space heating requirements in the heating season while increasing the cooling load in the cooling season. These impacts are not quantified in this methodology.

Ancillary Electric Savings Impacts

Reduction of ambient air infiltration into the refrigerated case due to improved gaskets, reduces the space heating requirements in the heating season while increasing the cooling load in the cooling season. These impacts are not quantified in this methodology.

[1] ADM Associates, Inc., Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation, February 2010, Table 5-3, Assumes baseline gaskets are 50% effective.
[2] *No source specified – update pending availability and review of applicable references.*

References

1. ADM Associates, Inc. "Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation" February 18, 2010, California Public Utilities Commission Energy Division
Available from:
http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf

Record of Revision

Record of Revision Number	Issue Date
1-16-17	12/31/2015
6-18-14	6/26/2018

Return to Table of Contents

APPENDIX P

EFFECTIVE USEFUL LIFE (EUL)

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

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

[1] ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[2] ENERGY STAR Dehumidifier Calculator https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[3] Savings Calculator for ENERGY STAR® Qualified Appliances (last updated October 2016) Available from: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products
[4] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[5] Ibid.
[6] http://energytrust.org/library/reports/resource_assesment/gasrptfinal_ss103103.pdf
[7] At least one manufactures warranty period. www.gss-ee.com/products.html

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Domestic Hot Water	Heat Pump Water Heater – Air Source (HPWH)[8]	Residential	10	DEER 2014 EUL ID: WtrHt-HtPmp
	Indirect Water Heater	Residential	11	DEER 2014 EUL ID: WtrHt-Res-Gas
	Storage Water Heater - Gas	Residential	11	DEER 2014 EUL ID: WtrHt-Res-Gas
	Storage Water Heater - Electric	Residential	13	DEER 2014 EUL ID: WtrHt-Res-Elec
	Instantaneous Water Heater	Residential	20	DEER 2014 EUL ID: WtrHt-Instant-Res
Domestic Hot Water - Control	Faucet – Low Flow Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Shower Restriction Valve	Residential	10	UPC[9]
	Shower Head – Low Flow	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner and Heat Pump – Refrigerant Charge Correction and Tune-Up	Residential	10	DEER 2014 EUL ID: HV-RefChrg
	Air Conditioner and Heat Pump – Right-Sizing	Residential	15	DEER[10]
	Air Conditioner, Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
	Air Conditioner – Room (RAC)	Residential	12	GDS[11]
	Air Conditioner – PTAC	Residential	15	DEER 2014 EUL ID: HVAC-PTAC
	Boiler, Hot Water – Steel Water Tube	Residential	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	Residential	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	Residential	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015

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

[9] UPC certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a. A standard that includes a lifecycle test consisting of 10,000 cycles without fail. 10,000 cycles is the equivalent of three users showering daily for more than nine years.

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

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

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

[12] U.S. DOE. "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces" and "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces." August 30, 2016. Available from: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217

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

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

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

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

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

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

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

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

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

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

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

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

Commercial and Industrial Measures

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

---

[23] Based on EUL's for similar control technology
[24] ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[25] ENERGY STAR Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx?5da4-3d90&5da4-3d90
[26] Energy Trust uses 30 years for commercial applications. http://energytrust.org/library/reports/Residentialource_assesment/gasrptfinal_ss103103.pdf. CEC uses 30 years for insulation in Title 24 analysis
[27] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (March 2015). Estimates range from 10 to 15 years.
[28] UI and CL&P, Program Savings Documentation for 2007 Program Year, September 2006, pg. 224
[29] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[30] EUL for this measure not available. Default to air compressor upgrade EUL from Ohio TRM. www.OhioTRM.org

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Domestic Hot Water (DHW)	Indirect Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Storage Tank Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Instantaneous Water Heater	C&I	20	DEER 2014 EUL ID: WtrHt-Instant-Com
	Heat Pump Water Heater - Air Source (HPWH)	C&I	10	DEER
DHW - Control	Faucet – Low Flow Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Showerhead – Low Flow	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Pre-Rinse Spray Valve	C&I	5	GDS
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner and Heat Pump – Refrigerant Charge Correction and Tune-Up	C&I	10	DEER 2014 EUL ID: HVAC-RecChg
	Air Conditioner – Unitary	C&I	15	DEER 2014 EUL ID: HVAC-airAC
	Air Conditioner – PTAC	C&I	15	DEER 2014 EUL ID: HVAC-PTAC
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: ClTwrPkgSys
	Chiller Tune-Up	C&I	5	WI EUL DB[31]
	Combination Boiler and Water Heater	C&I	20	DEER[32]
	Condensing Gas-Fired Unit Heater for Space Heating	C&I	18	Ecotope[33]
	Duct Sealing and Insulation	C&I	18	DEER
	EC Motors on HVAC Equipment	C&I	15	DEER 2014 EUL ID: Motors-Fan
	Economizer – Air Side, with Dual Enthalpy Control	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	Boiler, Hot Water – Steel Water Tube	C&I	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	C&I	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015

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

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

[34] U.S. DOE. “Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces” and “Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces.” August 30, 2016. Available from: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217

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

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

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

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

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

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

[40] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.2
[41] Placed on the Qualified Fixture List by Energy Star, according to the appropriate luminaire classification as specified in the Energy Star Program requirements for Luminaires, version 2.0. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns
[42] GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group
[43] DEER value for lighting occupancy sensors

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

Record of Revision

Record of Revision Number	Issue Date
EUL's originally listed in July 18, 2011 Order	7/18/2011
Additional EUL's posted on web site	Subsequent to 7/18/2011 Order
7-13-28	7/31/2013
6-14-1	6/19/2014
6-14-2	6/19/2014
6-15-4	6/1/2015
6-16-2	6/30/2016
1-17-8	12/31/2016
6-17-16	6/30/2017
9-17-11	9/30/2017
12-17-17	12/31/2017
3-18-21	3/31/2018
6-18-21	6/26/2018

Return to Table of Contents

GLOSSARY

Abbreviations, Acronyms, and Equation Variables	
$\overline{COP}$	Average coefficient of performance
η	Energy efficiency (0 -100%)
$\overline{\eta}$	Average energy efficiency (0 -100%)
$\overline{\Delta T}$	Average temperature difference
$\overline{EER}$	Seasonal average energy efficiency ratio over the cooling season BTU/watt-hour, (used for a particular climate/building)
ΔkW	Peak coincident demand electric savings
ΔkWh	Annual electric energy savings
ΔQ	Heat difference/loss
ΔT	Temperature difference
Δtherms	Annual gas energy savings
Δ	Change, difference, or savings
A	Amperage
AC	Air conditioning
ACCA	Air Conditioning Contractors of America
ACEEE	American Council for an Energy-Efficient Economy
ACL	Actual cooling load (Btu/hr) based on Manual J calculation
ACH	Air change per hour
AFUE	Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
AHAM	Association of Home Appliance Manufacturers
AHL	Actual heating load (Btu/hr) based on Manual J calculation
AHRI	Air Conditioning Heating and Refrigeration Institute
AHU	Air handling unit
AIA	American Institute of Architects
ANSI	American National Standards Institute
APU	Auxiliary power unit
area	Extent of space or surface
ARI	Air-Conditioning & Refrigeration Institute
ARRA	American Recovery and Reinvestment Act of 2009
ASHP	Air source heat pump
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
baseline	Baseline condition or measure
BLDC	Brushless DC electric motor
BTU	British Thermal Unit
BTUh	British Thermal Units per hour
CAC	Central air conditioner
CADR	Clean Air Delivery Rate (CFM)
Capacity	Cooling output rating, in Btu/hr
CAV	Constant air volume

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

EEPS	Energy Efficiency Portfolio Standard
EER	Energy efficiency ratio under peak conditions
EF	Energy factor
Eff	Efficiency
E_c	Combustion efficiency
Efficiency Vermont	State of Vermont Energy and Efficiency Initiatives
E_t	Thermal efficiency
EFLH	Equivalent full-load hours
EIA	Energy Information Administration, US
EISA	Energy Independence and Security Act (EISA) of 2007
ElecSF	Electric Savings Factor
ENERGY STAR®	U.S. Environmental Protection Agency voluntary program
Energy Trust	Energy Trust of Oregon, Inc.
EPA	Environmental Protection Agency (EPA), US
EPACT	Energy Policy and Conservation Act of 2005
EPDM	Ethylene propylene diene monomer roofing membrane
ERV	Energy recovery ventilation
ESF	Energy savings factor
EUL	Effective useful life
EFan	Evaporator fan
Exh	Exhaust
F	Factor
F_{elec}	Percentage of energy consumed that is derived from electricity
F_{gas}	Percentage of energy consumed that is derived from gas
FEMP	Federal Energy Management Program
FL	Full-load chiller efficiency under peak conditions
FLH	Full-load hours
Flow	Nozzle flow
FPFC	Four pipe fan coil
ft	Foot
ft^2	Square foot
GasSF	Gas Savings Factor
GDS	GDS Associates, Marietta, GA
Glazing area	Aperture area of glazing
GPD	Gallons Per Day
GPM	Gallons Per Minute
GSHP	Ground source heat pump
H_v	Heat of vaporization (latent heat), in Btu/lb
$H_2O_{savings}$	Water savings
HDD	Heating degree days - The number of degrees that a day's average temperature is below some baseline temperature, which represents the

	temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application.
HID	High intensity discharge lamp
hp	Horsepower
hp_{max}	Maximum motor horsepower
hp_{peak}	Horsepower at which motor achieves peak efficiency
HP	High performance
hrs	Hours
$hrs_{operating}$	Operating hours
HSPF	Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt-hour)
ht	Height
HVAC	Heating, ventilation, and air conditioning
$HVAC_c$	HVAC interaction factor for annual electric energy consumption
$HVAC_d$	HVAC interaction factor at utility summer peak hour
$HVAC_g$	HVAC interaction factor for annual natural gas consumption
HW	Hot water
IECC	International Energy Conservation Code
IEER	Integrated energy efficiency ratio
IESNA	Illuminating engineering Society of North America
IHR	Ice Harvest Rate (lbs/day)
IPLV	Integrated Part-Load Value, a performance characteristic, typically of a chiller capable of capacity modulation.
k	Thermal conductivity
$KBTUh_{in}$	Gas input rating (kBTU/h)
$kBTUh_{out}$	Heating output rating (kBTU/h)
kW	kilowatts
L	Length
LBNL	Lawrence Berkeley National Laboratory
leakage	Estimate of percent of units not installed in service territory
LED	Light emitting diode
LEED	Leadership in Energy and Environmental Design
LF	Load Factor
Load	Average total weight (lbs) of clothes per drying cycle
LPD	Lighting power density
LRAC	Long-run avoided cost
LSAF	Load shape adjustment factor
MEC	Metropolitan Energy Center
NAECA	National Appliance Energy Conservation Act of 1987
NBI	New Buildings Institute
NEA	National Energy Alliances
NEAT	National Energy Audit Tool
NEMA	National Electrical Manufacturers Association

NREL	National Renewable Energy Laboratory
NRM	National Resource Management
NSTAR	Operating company of Northeast utilities
NWPPC	Northwest Power Planning Council
NWRTF	Northwest Regional Technical Forum
NY DPS	New York State Department of Public Service
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
^{o}F	Degrees Fahrenheit
OSA	Outdoor supply air
PA Consulting	PA Consulting Group
PF	Power factor
Phase	Number of phases in a motor (1 or 3) Single Phase is a type of motor with low horsepower that operates on 120 or 240 volts, often used in residential appliances. Three phase is a motor with a continuous series of three overlapping AC cycles offset by 120 degrees. Three-phase is typically used in commercial applications.
PLR	Power loss reduction
PNNL	Pacific Northwest National Laboratory
PSC	Public Service Commission, New York State
PSF	Proper sizing factor
psia	Atmospheric pressure (lbs per square inch)
psig	Gauge pressure (lbs per square inch)
PSZ	Packaged single zone
PTAC	Package terminal air conditioner
PTHP	Packaged terminal heat pump
Q	Heat
$Q_{reduced}$	Reduced heat
Q_{reject}	Total heat rejection
r	Radius
RA	Return air
RAC	Room air conditioner
RE	Recovery efficiency
RECS	Residential Energy Consumption Survey
RESNET	Residential Energy Services Network
RH	Reduced heat
RLF	Rated load factor
RPM	Revolutions per minute
R-value	A measure of thermal resistance particular to each material
S	Savings
SAPA	State Administrative Procedure Act
SBC	System Benefit Charge
SCFM	Standard cubic feet per minute @ 68 ^{o}F and 14.7 psi standard condition

SEER	Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
SF	Square foot
SHGC	Solar heat gain coefficient
SL	Standby heat loss
Staff	NYS Department of Public Service Staff
standby	Standby Power (watts)
T	Temperature
TAF	Temperature adjustment factor
TDA	Total Display Area (ft^2)
TDEC	Total Daily Energy Consumption
TEFC	Totally enclosed fan cooled
th	Thickness
therm	Unit of heat
THR	Total heat rejection
$Throttle_{fac}$	Throttle factor
TMY	Typical meteorological year
tons	Tons of air conditioning
tons/unit	Tons of air conditioning per unit, based on nameplate data
TRC	Total Resources Cost
TRF	Thermal Regain Factor
TRM	Technical Resource Manual
UA	Overall heat loss coefficient (BTU/hr-°F)
UEF	Uniform Energy Factor
unit	Measure
units	Number of measures installed under the program
UPC	Uniform Plumbing Code under the International Association of Plumbing and Mechanical Officials
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
U-value	Measure of heat loss in a building element/overall heat transfer co-efficient
V	Volt
v	Volume
VAV	Variable air volume
VSD	Variable speed drive
W	watts
W_{ctrl}	Total wattage of controlled lighting (watts)
Wisconsin PSC	State of Wisconsin Public Service Commission

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

Record of Revision

Record of Revision Number	Issue Date
0	12/10/2014
6-15-4	6/1/2014
1-17-9	12/31/2016
6-17-17	6/30/2017
9-17-12	9/30/2017
12-17-18	12/31/2017
3-18-22	3/31/2018
6-18-22	6/26/2018

Return to Table of Contents