Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
12-19-1	R	12/23/2019	1/1/2021	R/MF Dishwasher	Updated Electric and Gas Savings Factor values and source for unknown water heating fuel; Revised CF value to reflect NY peak	Pg. 23
12-19-2	R	12/23/2019	1/1/2021	R/MF Insulation – Opaque Shell	Updated Measure Description to eliminate redundancy; Added footnote identifying disparity between predicted and realized savings	Pg. 64
12-19-3	R	12/23/2019	1/1/2021	R/MF Boiler, Furnace and Unit Heater	Added language to Measure Description regarding baseline; Applied consistent formatting for efficiency terms	Pg. 124
12-19-7	R	12/23/2019	1/1/2021	R/MF Interior and Exterior Lighting	Updated Operating Hours assumptions, values and sources	Pg. 193
12-19-8	R	12/23/2019	1/1/2021	R/MF Pool Heater	Modified methodology to estimate savings based on equipment capacity; Added clarification regarding standing pilots	Pg. 207
12-19-15	R	12/23/2019	1/1/2021	C/I Electronically Commutated (EC) Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	Revised methodology to rely on wattage; Updated values and sources for operating hours and power factor assumptions; Updated COP variable	Pg. 476
12-19-16	R	12/23/2019	1/1/2021	C/I Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM), for Refrigerated Case or Walk-In Cooler/Freezer	Updated Operating Hours values and sources; Updated COP variable	Pg. xx
12-19-17	R	12/23/2019	1/1/2021	Appendix P	Updated EUL entries for all measures contained in this Record of Revision	Pg. 765

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between September 28, 2019 – December 23, 2019.

APPLIANCE

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 Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer 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 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	Based on ENERGY STAR®.[5]
$F_{machine}$	0.44	Based on ENERGY STAR®.[6]
$ElecSF_{wh}$	Electric WH: 1.00 Gas WH: 0 Other: 0 Unknown: 0.20	Based on NYSERDA Residential Statewide Baseline Study of New York State – July 2015.[7] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration of delivery mechanism.
$GasSF_{wh}$	Electric WH: 0 Gas WH: 1.00 Other: 0 Unknown: 0.54	Based on NYSERDA Residential Statewide Baseline Study of New York State – July 2015.[8] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration of delivery mechanism.

[5] ENERGY STAR® Appliance Calculator
[6] Ibid
[7] NYSERDA Residential statewide Baseline Study. Volume 1: Single Family Report, Table 38: Water Heating Fuel Type by Climate Zone. Overall statewide averages applied. ElecSF and GasSF "unknown" factors may not sum to 100% due to the presence of other water heating fuels. In the condition of other water heating fuels in home, the designation "Other" shall be applied.
[8] Ibid.

Variable	Value	Notes
RE_{elec}	0.98	Recovery efficiency of typical electric storage type water heater. [9]
RE_{gas}	0.75	Recovery efficiency of typical gas storage type water heater.[10]
hrs	301	Code of Federal Regulations. [11]
CF	0.029	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.029.[12]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a residential dishwasher as defined in the Measure Description section above with type equivalent to the efficient 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.

[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*

[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 8,760 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) and peak range was adjusted to reflect New York peak time (the hour ending in 5PM) from Illinois peak time (1PM to the hour ending 5PM).

[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

Dishwasher Type	kWh_{ee}
Compact	203
Standard	270

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. NYSERDA Residential Statewide Baseline Study of New York State – July 2015
   Available from:
   https://www.nyserda.ny.gov/About/Publications/Building%20Stock%20and%20Potential%20Studies/Residential%20Statewide%20Baseline%20Study%20of%20New%20York%20State

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

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
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
12-19-1	12/23/2019

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BUILDING SHELL

INSULATION - OPAQUE SHELL

Measure Description

This measure covers the installation of wall and ceiling insulation to reduce the thermal conductance of the building envelope. Energy and demand saving are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured in order to estimate energy savings. This measure is only applicable as a retrofit in existing single and multi-family buildings, excluding gut rehab/major renovation projects. These projects entail whole-building envelope alterations that trigger more stringent code provisions, limiting potential incremental savings.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{ft^2}{1{,}000} \times \left(\frac{\Delta kWh}{1{,}000 ft^2}\right)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{ft^2}{1{,}000} \times \left(\frac{\Delta kW}{1{,}000 ft^2}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = \frac{ft^2}{1{,}000} \times \left(\frac{\Delta therms}{1{,}000 ft^2}\right)$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
ft^2	= Square footage of conditioned floor area affected by installation of opaque shell insulation
$\Delta kWh/1{,}000ft^2$	= Annual electric energy savings per thousand square feet of conditioned area
$\Delta kW/1{,}000ft^2$	= Peak coincident demand electric savings per thousand square feet of conditioned area
$\Delta therms/1{,}000ft^2$	= Annual gas energy savings per thousand square feet of conditioned area
CF	= Coincidence factor
1,000	= Conversion factor, ft^2 equals 1,000 ft^2

Summary of Variables and Data Sources

Variable	Value	Notes
ft^2		From application.
$\Delta kWh/1{,}000ft^2$		Look up based on building type, location, HVAC type, insulation type and existing and installed insulation R-values in Appendix E.
$\Delta kW/1{,}000ft^2$		Look up based on building type, location, HVAC type, insulation type and existing and installed insulation R-values in Appendix E.
$\Delta therms/1{,}000ft^2$		Look up based on building type, location, HVAC type, insulation type and existing and installed insulation R-values in Appendix E.
CF	0.69	

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a series of prototypical residential buildings. The prototype building characteristics are described in Appendix A. The unit energy and demand savings calculated from the building prototype simulation models are shown in Appendix E. The savings are tabulated by building type and HVAC system type across a range of pre-existing (baseline) and upgraded insulation R-values.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[16]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a building envelope with insufficient insulation (i.e., not compliant with all applicable construction code requirements). Energy savings over a variety of baseline wall and ceiling insulation levels are listed in Appendix E.[17] The baseline R-value must be captured and included in the program application. Interpolation of the data in Appendix E is permitted.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential opaque building shell with increased insulation meeting or exceeding applicable construction code requirements. Energy savings over a variety of measure wall and ceiling insulation levels are listed in Appendix E. The data in Appendix E represents the total R-value of the existing plus added insulation. The installed R-value must be captured and

[16] 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.

[17] The prototype modeling used to calculate energy savings was conducted between 2007 and 2010 and reflects 2007 code as baseline for all relevant building components except insulation. The baseline condition for insulation is the as-found condition. Therefore, except for insulation, the building is assumed to be built to 2007 code specifications. This will affect the internal load and HVAC efficiency assumption, which will in turn impact predicted vs. actual savings.

included in the program application. Interpolation of the data in Appendix E is permitted.

Opaque shell insulation improvements performed under this measure shall be installed such that that all altered envelope components comply with all federal, state, local and municipal codes and standards applicable to alterations to existing buildings, including but not limited to Section R503.1 of ECCCNYS 2016[18] and NYCECC 2016[19] requiring all existing ceiling, wall, and floor cavities exposed during construction to be filled with insulation. Thermal envelope components not altered as part of this measure (e.g. continuous insulation in wood-framed buildings) are not required to meet code for compliance.

Operating Hours

HVAC system operating hours are embedded into the deemed savings shown in Appendix E and vary by building type. See Appendix A for details on prototype building simulation parameters.

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. ECCCNYS 2016, per IECC 2015; Section R503 Alterations
   Available from: https://codes.iccsafe.org/content/IECC2015NY-1/chapter-5-re-existing-buildings
3. NYCECC 2016; Section R503 Alterations
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR5.pdf&section=energy_code_2016

[18] ECCCNYS 2016, Section R503 Building Thermal Envelope
[19] NYCECC 2016, Section R503 Building Thermal Envelope

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-25	7/31/2013
7-13-38	7/31/2013
9-18-2	9/28/2018
3-19-2	3/29/2019
12-19-2	12/23/2019

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

BOILER, FURNACE AND UNIT HEATER

Measure Description

This measure covers the installation of high efficiency gas fired furnaces, boilers, and unit heaters used for space heating. The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state, local and municipal codes and standards.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times kBTU/h_{in} \times \left(\frac{Eff_{ee}}{Eff_{baseline}} - 1\right) \times \frac{EFLH_{heating}}{100}$$

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
$kBTU/h_{in}$	= Fuel Input Rating per unit
Eff_{ee}	= Efficiency of energy efficient condition or measure
$Eff_{baseline}$	= Efficiency of baseline condition or measure
$EFLH_{heating}$	= Heating equivalent full-load hours
100	= Conversion factor (100 kBTU/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTU/h_{in}$		Nominal heating input capacity is the nameplate input rating of the unit in kBTU/h, from application.
$Eff_{baseline}$	See Baseline Efficiency	Baseline established by applicable energy conservation code, climatic zone, equipment type and size, fuel source, as well as system configuration.
Eff_{ee}	See Compliance Efficiency	From application; use metrics consistent with baseline $EFLH_{heating}$

Variable	Value	Notes
$EFLH_{heating}$		Lookup based on building type and location, Appendix G

Efficiency is expressed as the ratio between the fuel input relative to the output. The efficiency of furnaces, boilers and unit heaters is customarily evaluated on the basis of one or more of three standards, and are referred to as Thermal Efficiency (E_t), Combustion Efficiency, (E_c) or Annual Fuel Utilization Efficiency (AFUE).

Presently, the AFUE value is only applicable to smaller units. For larger units, use thermal and combustion efficiencies referenced on manufacturer's nameplate data in accordance with nationally recognized standards and testing agencies.

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline efficiency for residential furnaces, boilers, and unit heaters ($\eta_{baseline}$) is defined by the Code of Federal Regulations and subsequently adopted by the Energy Conservation Code of New York State[20], and the New York City Energy Conservation Code[21] as shown below.

Systems Serving Single-Family Homes or Single Units[22]

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	All Capacities	0.80 AFUE	0.80 AFUE
Boiler, Hot Water, Gas Fired	All Capacities	0.82 AFUE	0.82 AFUE
Boiler, Steam, Gas Fired	All Capacities	0.80 AFUE	0.80 AFUE

[20] ECCCNYS 2016, Table C403.2.3(4) and Table C403.2.3(5)
[21] NYCECC 2016; Table C403.2.3(4) and Table C403.2.3(5)
[22] 10 CFR 430.32(e)

Systems Serving Multiple Dwelling Units

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.78 AFUE or 0.80 Et	0.78 AFUE or 0.80 Et
	≥ 225 kBTU/h	0.80 Et	0.80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.80 AFUE	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et	0.80 Et
	> 2,500 kBTU/h	0.82 Ec	0.82 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et	0.79 Et
	> 2,500 kBTU/h	0.79 Et	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et	0.77 Et
	> 2,500 kBTU/h	0.77 Et	0.77 Et

Compliance Efficiencies from which Incentives are Calculated

Equipment Type	Size Range	Minimum Compliance Efficiency for Climate Zones 4, 5 and 6	Minimum Compliance Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.92 AFUE	0.92 AFUE
	≥ 225 kBTU/h	0.90 Et	0.90 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.83 Ec	0.83 Ec
Boiler, Non-Condensing, Hot Water, Gas Fired	< 300 kBTU/h	0.85 AFUE	0.85 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.85 Et	0.85 Et
	> 2,500 kBTU/h	0.88 Ec	0.88 Ec
Boiler, Condensing, Hot Water, Gas Fired	< 300 kBTU/h	0.90 AFUE	0.90 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.90 Et	0.90 Et
	> 2,500 kBTU/h	0.93 Ec	0.93 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.82 AFUE	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et	0.82 Et
	> 2,500 kBTU/h	0.82 Et	0.82 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.82 AFUE	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et	0.82 Et
	> 2,500 kBTU/h	0.82 Et	0.82 Et

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 commercial 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

High efficiency furnaces may be packaged with high efficiency cooling equipment and/or electronically commutated blower motors, which may provide electricity savings. Draft fans, when present, will increase electricity consumption.

References

1. 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
2. ECCCNYS 2016, per IECC 2015; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers.
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
3. NYCECC 2016; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas-And Oil-Fired Boilers
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
4. 2015 ASHRAE Handbook – HVAC Applications, Table 4: Comparison of Service Life Estimates

Record of Revision

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1	10/15/2010
7-13-32	7/31/2013
8-13-1	8/31/2013
6-15-5	6/1/2015
1-16-2	12/31/2015
6-17-5	6/30/2017
12-19-3	12/23/2019

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LIGHTING

INTERIOR AND EXTERIOR LIGHTING

Measure Description

This measure covers the installation of energy efficient lighting equipment including LED lamps and improved lighting fixtures installed in interior and exterior locations. These technologies, taken separately or combined into an energy efficient lighting fixture, provide the required illumination at reduced input power.

Beginning January 2014, the Energy Independence and Security Act of 2007 (EISA) regulations stipulated typical 60W and 40W lamp wattages to comply with 43W and 29W lamp wattage standards for rated lumen output ranges of 750-1049 and 310-749 lumens, respectively. Deemed baseline values for this measure will apply wattages based on lamp type and light output (lumens).[23]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{(W_{baseline} - W_{ee})}{1{,}000} \times hrs \times HVAC_g$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Summer Peak Coincident Demand Savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
W	= Rated wattage of lamp and/or fixture (Watts)
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
1,000	= Conversion factor, one kW equals 1,000 Watts
CF	= Coincidence factor
hrs	= Lighting operating hours

[23] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 86

$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor for peak demand at NYISO coincident summer peak hour
$HVAC_g$ = HVAC interaction factor for annual natural gas consumption (therms/kWh)

Summary of Variables and Data Sources

Variable	Value	Notes
units		Number of lamps sold/distributed under the program, from application
W_{ee}		Energy efficient measure Watts, from application
$W_{baseline}$		Baseline measure Watts, from application or default values from applicable table in "Baseline Efficiencies…" section below. Existing wattage shall be used when known. Baseline tables (below) shall be used when program structure does not allow for collection of existing conditions (e.g., point-of-sale rebates).
hrs	Interior: 986 Exterior: 2,117 Unknown: 1,095	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. "Unknown" is not a valid selection for direct install programs.
$HVAC_c$	Exterior and Unconditioned Spaces: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$	Exterior and Unconditioned Space: 0	HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_g$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual natural gas energy consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	Interior: 0.082 Exterior: 0	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting.

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

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor for interior lighting is 0.082. This factor was derived from an examination of studies throughout New England that calculated coincidence factors based on the definition of system peak period at the time, as specified by ISO-New England.[24]

Because exterior lighting is assumed to operate during off-peak hours only, the prescribed coincidence factor for exterior lighting is 0.0.

Baseline Efficiencies from which Energy Savings are Calculated

Rated wattage baseline values should reflect the guidance noted below based on bulb type and lumens in accordance with EISA standards. [25]

General Service Lamps

Baseline wattage for general service lamps are found in the table below. Per EISA 2007 guidelines, a general service lamp is defined as a standard incandescent or halogen type lamp that:

(1) Is intended for general service applications;
(2) Has a medium screw base;
(3) Has a lumen range of not less than 310 lumens and not more than 2,600 lumens
(4) Is capable of being operated at voltage range at least partially within 110 and 130 volts.

Certain lamp types are exempt from EISA compliance, including reflector lamps (see Reflector/Flood Lamps section below), decorative and globe shape lamps (see Specialty Lamps section below) and three-way lamps. Baseline wattage for any of these exempt lamp types shall reflect the values in column (c) of the table below, with the exception of those lamps defined in the Specialty Lamps or Reflector/Flood Lamps sections. All other general service lamps shall use the baseline wattage values in column (b), corresponding to the applicable lumen range identified in column (a). For standard lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage shall be used. For a complete list and definitions of EISA-exempt lamp types, reference Sec. 321: Efficient Light Bulbs of Public Law 110-140.[26]

Lumen Range **(a)**	**Post-EISA 2007 Incandescent Equivalent $W_{baseline}$** **(b)**	**EISA-Exempt Incandescent Equivalent $W_{baseline}$** **(c)**
310 – 449	25	25
450 – 799	29	40
800 – 1,099	43	60
1,100 – 1,599	53	75
1,600 – 1,999	72	100
2,000 – 2,600	72	150

[24] Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures, Spring 2007, Table i-1
[25] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 89[26] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 82-86
[26] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 82-86

Specialty Lamps[27]

Baseline wattage for specialty lamps are found in the table below. Specialty lamps are defined as medium screw-base lamps that are globe, bullet, candle or decorative shaped. For specialty lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage should be used.

Lumen Range (decorative) (a)	Lumen Range (globe) (b)	Post-EISA 2007 Incandescent Equivalent $W_{baseline}$ (c)	EISA-Exempt Incandescent Equivalent $W_{baseline}$ (d)
70 – 89		10	10
90 – 149		15	15
150 – 299	250 – 349	25	25
300 – 499	350 – 499	29	40
500 – 699	500 – 574	43	60
	575 – 649	53	75
	650 – 1,099	72	100
	1,100 – 1,300	72	150

Reflector/Flood Lamps[28]

Baseline wattage for reflector and flood type lamps are found in the table below. For reflector and flood lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage should be used.

Bulb Type (a)	Lumen Range (b)	$W_{baseline}$ (c)
ER30, BR30, BR40, or ER40	200 – 299	30
	300 – 449	40
	450 – 499	45
	500 – 1,419	65
R20	200 – 299	30
	300 – 449	40
	400 – 449	40
	450 – 719	45
All other R, PAR, ER, BR, BPAR, or similar bulb shapes, with diameter >2.25", other than those listed above	200 – 299	30
	300 – 599	40
	600 – 849	50
	850 – 999	55
	1,000 – 1,300	65

[27] The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures; Chapter 21: Residential Lighting Evaluation Protocol, National Renewable Energy Laboratory, December 2014, p. 8-11

[28] State of Pennsylvania Technical Reference Manual, PA Public Utilities Commission, June 2016, p. 21-22

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an efficient lighting product (lamp or fixture) meeting the minimum requirements of the current effective version of ENERGY STAR® Lamps specification, ENERGY STAR® Luminaires specification or the Design Lights Consortium qualified products list.

Operating Hours

Interior

Hours of operation for interior lighting is estimated to be 2.7 operating hours per day or 986 (2.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in Massachusetts and portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse.[29]

Exterior

Hours of operation for exterior lighting is estimated to be 5.8 operating hours per day or 2,117 (5.8 x 365) hours per year. This value is derived from on-site lighting inventories of homes in Massachusetts and portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse.[30]

Unknown

Hours of operation for lighting installed in an unknown location is estimated to be 3.0 operating hours per day or 1,095 (3.0 x 365) hours per year. This value is derived from on-site lighting inventories of homes in Massachusetts and portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse.[31]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

[29] NMR Group Inc., "RLPNC Study 17-9 2017-18 Residential Lighting Market Assessment Study", March 28, 2018. Table 2. Hours of use were calculated by taking the sum product of the HOU-Snapback Adjusted and 2018 Proportion of LEDs columns, divided by the sum of the 2018 Proportion of LEDs column in Table 2 of the study, excluding the "Exterior" row.

[30] NMR Group Inc., "RLPNC Study 17-9 2017-18 Residential Lighting Market Assessment Study", March 28, 2018. Table 2. Hours of use is taken from the "Exterior" row in Table 2: Proportion of Bulbs by Room and Type.

[31] NMR Group Inc., "RLPNC Study 17-9 2017-18 Residential Lighting Market Assessment Study", March 28, 2018. Table 2. Hours of use is taken from the "Household" row in Table 2: Proportion of Bulbs by Room and Type, which is the weighted average of HOU in all room types.

References

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   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_179_LtgMarketAssessment_28March2018_FINAL.pdf
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5. State of Pennsylvania Technical Reference Manual, PA Public Utilities Commission, June 2016, p. 21-22
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1	10/15/2010
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6-15-3	6/1/2015
1-16-3	12/31/2015
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9-17-2	9/30/2017
12-19-6	12/23/2019
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OTHER

POOL HEATER

Measure Description

This measure covers the installation of high efficiency natural gas pool heaters in residential applications.[32] Gas-fired pool heaters are designed for heating non-potable water and employ natural gas burners. High-efficiency natural gas heaters can have thermal efficiency ratings as high as 95%. Pool heaters must have a thermal efficiency rating of 84% or greater to qualify for estimated energy savings using this measure.[33]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times (therms/(kBTU/h_{in})_{baseline} - therms/(kBTU/h_{in})_{ee}) \times kBTU/h_{in}$$

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
therms/(kBTU/h_{in})	= Annual gas consumption per pool heater heating capacity
kBTU/h_{in}	= Pool heater input heating capacity, in kBTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
therms/(kBTU/h_{in})$_{baseline}$	1.46	From the annual energy consumption table below, based on a thermal efficiency rating of 82%.

[32] Similar to other measures in the NY TRM, this measure will continue to be reviewed for accuracy and for potential updates, based on up-take in programs, changes in codes and standards, and the availability of other measure-specific information.

[33] 10 CFR 430.32.(k)(1)

Variable	Value	Notes
therms/(kBTU/h_{in})$_{ee}$		Look up from energy consumption table below based on thermal efficiency rating of fuel efficient pool heater. Interpolation may be performed for pool heater efficiencies not listed, above 84%.
kBTU/h_{in}		Pool heater input capacity as indicated on equipment nameplate, from application.

Annual Energy Consumption[34]

Thermal Efficiency (%)	Annual Gas Consumption (therms/(kBTU/h_{in}))
82 (baseline)	1.46
84	1.38
86	1.34
90	1.28
95	1.22

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a gas-fired pool heater with a thermal efficiency of 82% as mandated by federal standards.[35]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a gas-fired pool heater that has a thermal efficiency of 84% or greater.[36]

Operating Hours

Pool heater run hours are embedded in the values found in the Annual Energy Consumption table provided above. The derivation assumes a 250-kBTU/h pool heater, 26.5% of heaters equipped with a pilot with an input rate of 1-kBTU/h, an average pilot operating hours of 4,464 hours per year, and a distribution range of pool operational hours from 235 to 8,760 per year. [37]

[34] US DOE, Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters, Chapter 7, Table 7.4.2: Annual Energy Consumption for Gas-Fired Pool Heaters. The derivation assumes a 250-kBTU/h pool heater and 26.5% of heaters equipped with a pilot with an input rate of 1-kBTU/h.
[35] 10 CFR 430.32.(k)(1)
[36] Compliance requirement based on SoCal Gas minimum thermal efficiency to qualify for incentive (accessed 11/27/2018)
[37] A continuously burning pilot is prohibited by the Code of Federal Regulations. However, removing the 26.5% of pool heaters with a pilot from the analyzed population, assuming these are distributed across efficiency levels, will not change nominal savings.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Analysis of baseline and high-efficiency gas pool heaters conducted using the DOE test procedure suggests that auxiliary and stand-by electric loads are slightly higher for more efficient equipment.[38] The magnitude of these effects is considered negligible relative to anticipated gas savings and electric impacts have thus been excluded from the prescribed methodology.

References

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[38] US DOE, Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters, Chapter 7, Table 7.4.2: Annual Energy Consumption for Gas-Fired Pool Heaters

REFRIGERATION

ELECTRONICALLY COMMUTATED (EC) MOTOR - REFRIGERATED CASE OR WALK-IN COOLER/FREEZER EVAPORATOR FAN

Measure Description

This measure covers replacement of single-phase shaded pole (SP) or permanent split capacitor (PSC) evaporator fan motors with electronically commutated (EC) motors in walk-in and reach-in refrigerated cases. These high-efficiency motors achieve savings by reducing evaporator fan power and through interactive effects with the system's compressor. EC motors introduce less waste heat into the refrigerated case, reducing the total refrigeration load. This measure is only applicable in a 1:1 replacement of existing, single-phase SP or PSC motor output. This measure applies to equipment manufactured before January 1, 2009 only, as the Code of Federal Regulations requires the use of EC or three-phase motors in evaporator fans in equipment manufactured on or after that date.[39]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings for Walk-In Coolers/Freezers

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{EFan} + \Delta kWh_{RH}$$

$$\Delta kWh_{EFan} = units \times \left(\frac{W_{EFan}}{1{,}000}\right) \times F_{PA} \times F_{EFan} \times hrs_{EFan}$$

$$\Delta kWh_{RH} = \Delta kWh_{EFan} \times COP_{ref} \times 0.284$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \Delta kW_{EFan} + \Delta kW_{RH}$$

$$\Delta kW_{EFan} = units \times \left(\frac{W_{EFan}}{1{,}000}\right) \times F_{PA} \times F_{EFan} \times CF$$

$$\Delta kW_{RH} = \Delta kW_{EFan} \times COP_{ref} \times 0.284$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

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

[39] 10 CFR 431.306

$\Delta therms$ = Annual gas energy savings
ΔkWh_{EFan} = Annual electric savings due to evaporator fan motor replacement
ΔkWh_{RH} = Annual electric savings due to reduced heat from evaporator fan motor replacement
ΔkW_{EFan} = Summer Peak Coincident Demand Savings due to evaporator fan motor replacement
ΔkW_{RH} = Summer Peak Coincident Demand Savings due to reduced heat from evaporator fan motor replacement
units = Number of measures installed under the program
W_{EFan} = Nameplate wattage of existing evaporator fan motor
1,000 = Conversion factor, one kW equals 1,000 W
F_{PA} = Power factor
F_{EFan} = Reduction of load by replacing evaporator fan motor
hrs_{EFan} = Evaporator fan motor annual operating hours
COP_{ref} = Coefficient of performance of refrigeration equipment
0.284 = Conversion factor from kW to Tons of refrigeration (Tons/kW)
CF = Coincidence factor

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings for Refrigerated Cases

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{CM} + \Delta kWh_{RH}$$

$$\Delta kWh_{CM} = units \times \left(\frac{W_{EFan}}{1{,}000}\right) \times F_{PA} \times F_{CM} \times hrs_{CM}$$

$$\Delta kWh_{RH} = \Delta kWh_{CM} \times COP_{ref} \times 0.284$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \Delta kW_{CM} + \Delta kW_{RH}$$

$$\Delta kW_{CM} = units \times \left(\frac{W_{EFan}}{1{,}000}\right) \times F_{PA} \times F_{CM} \times CF$$

$$\Delta kW_{RH} = \Delta kW_{CM} \times COP_{ref} \times 0.284$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:
ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta therms$ = Annual gas energy savings

ΔkWh_{CM} = Annual electric savings due to case motor replacement
ΔkWh_{RH} = Annual electric savings due to reduced heat from case motor replacement
ΔkW_{CM} = Summer Peak Coincident Demand Savings due to case motor replacement
ΔkW_{RH} = Summer Peak Coincident Demand Savings due to reduced heat from case motor replacement
units = Number of measures installed under the program
W_{EFan} = Nameplate wattage of existing evaporator fan
F_{PA} = Power adjustment factor
F_{CM} = Reduction of load by replacing case motor
hrs_{CM} = Case motor annual operating hours
COP_{ref} = Coefficient of performance of refrigeration equipment
1,000 = Conversion factor, one kW equals 1,000 W
0.284 = Conversion factor from kW to Tons of refrigeration (Tons/kW)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
W_{EFan}	$= Volts \times Amps \times \sqrt{Phase}$	Based on nameplate Volts, Amps, and Phase of existing evaporator fan.
F_{PA}	0.601	Oak Ridge National Laboratory. [40]
hrs_{EFan}	On/Off Control: 5,571 Multistep Control: 6,062 No Cooler Control: 8,567	Based on refrigeration control type.[41]
hrs_{CM}	8,573	PG&E.[42]
F_{EFan}	0.65	Based on numerous pre and post meter readings conducted by NRM and supported by RLW Analytics evaluation.[43]
F_{CM}	Shaded Pole: 0.44 PSC: 0.3	US DOE.[44]
COP_{ref}		From application; COP = 3.517/(kW/ton), where kW/ton is the rated efficiency of the compressor in input kW per ton of refrigeration capacity.
CF	1.0	

[40] Oak Ridge National Laboratory, Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits, September 2015, page 5.
[41] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, Table 4. Average Parameters – EF Motors pg. 6. The study analyzes reach-in and walk-in coolers and freezers.
[42] PG&E Work Paper PGE3PREF124 Revision 2. Average of operating hours of medium temperature applications and low temperature applications.
[43] Small Business Services, Custom Measure Impact Evaluation, RLW Analytics, Inc., March 2007.
[44] US DOE, Commercial Refrigeration Equipment (CRE) Technical Support Document, table 5.6.4. Ratio of actual power (watts) of EC motors vs actual power (watts) of shaded-pole motor and PSC motor.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[45]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline case is a walk-in cooler/freezer or refrigerated display case with shaded pole or permanent split capacitor (PSC) evaporator fan motors.

Compliance Efficiency from which Incentives are Calculated

The compliance case is a walk-in cooler/freezer or refrigerated display case with electronically commutated (EC) evaporator fan motors with full load efficiency exceeding that prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 and/or 10 CFR 431.25 as applicable.

Operating Hours

The annual operating hours of a walk-in cooler or freezer evaporator fan motor without controls is derived as 97.8% x 8,760 = 8,567 hours. The effective full load annual run time of evaporator fans with on/off control are assumed to be 63.6% x 8,760 = 5,571 hours, while the effective full load annual run time of evaporator fans with multispeed control are assumed to be 69.2% x 8,760 = 6,062 hours.[46]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Reduction in evaporator fan power reduces waste heat that must be displaced by the compressor. Interactive effects are addressed in the prescribed energy savings calculation methodology.

References

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[45] *No source specified – update pending availability and review of applicable references.*
[46] Cadmus, Commercial Refrigeration, Loadshape Project, October 2015

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1	10/15/2010
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9-17-9	9/30/2017
9-18-15	9/28/2018
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REFRIGERATION

EVAPORATOR FAN MOTOR – WITH PERMANENT MAGNET SYNCHRONOUS MOTOR (PMSM), FOR REFRIGERATED CASE OR WALK-IN COOLER/FREEZER

Measure Description

This measure covers the replacement of shaded pole (SP), permanent split capacitor (PSC), or electrically commutated (EC) evaporator fan motors with permanent magnet synchronous motors (PMSM) in commercial refrigeration equipment. PMSMs provide increased efficiency over other motors requiring less energy to operate and introducing less heat into the refrigerated case, which reduces the total refrigeration load.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual 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
W	= Rated motor wattage
Eff	= Motor efficiency
COP_{ref}	= Coefficient of performance of refrigerator compressor
hrs	= Annual operating hours
CF	= Coincidence Factor
1,000	= Conversion factor, one kW equals 1,000 W

Summary of Variables and Data Sources

Variable	Value	Notes
W_{ee}		From application.
$Eff_{baseline}$	Shaded Pole: 0.20 PSC: 0.29 EC: 0.66	For replacement of motors in reach-in cases, look up based on existing motor type.[47] For new construction, unknown existing conditions and walk-in coolers and freezers, use value associated with EC motors.
Eff_{ee}	0.73	Oak Ridge National Laboratory[48]
COP_{ref}		From application; COP = 3.517/(kW/ton), where kW/ton is the rated efficiency of the compressor in input kW per ton of refrigeration capacity.
hrs	On/Off Control: 5,571 Multistep Control: 6,062 No Control: 8,567	Based on refrigeration control type.[49]
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[50]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for walk-in coolers or freezers manufactured on or after January 1, 2009 is an EC motor[51] with full load efficiency as prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 and 10 CFR 431.25, as applicable. The baseline condition for walk-in coolers or freezers manufactured before January 1, 2009 and reach-in refrigerated display cases is equivalent to the equipment being replaced (shaded pole or PSC motor). Baseline equipment shall be assumed to be of equivalent speed and horsepower to the efficient case.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a PMSM installed in a commercial refrigerated reach-in display case or walk-in cooler/freezer with full-load efficiency exceeding that prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 or 10 CFR 431.25, as applicable.

[47] U.S. DOE, Technical Support Document Commercial Refrigeration Equipment, Chapter 5, Table 5.6.4: Details for Evaporator Fan Motor Design Option
[48] ORNL, Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits, p 5
[49] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, Table 4. Average Parameters – EF Motors pg. 6. The study analyzes reach-in and walk-in coolers and freezers.
[50] *No source specified – update pending availability and review of applicable references.*
[51] 10 CFR 431.306

Operating Hours

The annual operating hours of a walk-in cooler or freezer evaporator fan motor without controls is derived as 97.8% x 8,760 = 8,567 hours. The effective full load annual run time of evaporator fans with on/off control are assumed to be 63.6% x 8,760 = 5,571 hours, while the effective full load annual run time of evaporator fans with multispeed control are assumed to be 69.2% x 8,760 = 6,062 hours.[52]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Reduction in evaporator fan power reduces waste heat that must be displaced by the compressor. The refrigeration savings are addressed in the prescribed energy savings calculation methodology.

References

1. 10 CFR 431.306 Energy conservations standards and their effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=bf918c7935d524eeb5d031252bb66fba&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1306
2. Department of Energy; Technical Support Document Commercial Refrigeration Equipment, Chapter 5: Engineering Analysis, August 2013
   Available from:
   https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cre2_nopr_tsd_2013_08_28.pdf
3. Cadmus, Commercial Refrigeration Loadshape Project, October 2015
   Available from: www.neep.org/file/3530/download?token=NnVjANtf
4. Oak Ridge National Laboratory, Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits
   Available from: https://info.ornl.gov/sites/publications/files/Pub58600.pdf
5. Analysis of Equipment and Practices in the Reclamation Industry
   Available from: https://www.epa.gov/sites/production/files/2015-08/documents/analysis_of_equipment_and_practices_in_the_reclamation_industry.pdf
6. 10 CFR 431.446 Small electric motors energy conservation standards and their effective dates
   Available from: https://www.ecfr.gov/cgi-bin/textidx?SID=f7f8d64bb400ae3dc2d13f131cf116bb&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1446

[52] Cadmus, Commercial Refrigeration, Loadshape Project, October 2015

7. 10 CFR 431.25 Energy conservation standards and effective dates
   Available from: https://www.ecfr.gov/cgi-bin/textidx?SID=070fc8cd95943842a1e7a6f793d73496&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_125

Record of Revision

Record of Revision Number	Issue Date
6-19-3	6/28/2019
12-19-16	12/23/2019

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APPENDIX P

EFFECTIVE USEFUL LIFE (EUL)

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance	Air Purifier	Residential	9	ENERGY STAR® Calc[53]
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[54]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[55]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[56]
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[57]
Appliance Control	Advanced Power Strip (APS)	Residential	8	DEER 2014 EUL ID: Plug-OccSens
Appliance Recycling	Air Conditioner - Room (RAC) Recycling	Residential	3	DEER 2014 EUL ID: HV-RAC-RUL
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef
	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr

[53] 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
[54] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[55] ENERGY STAR® Dehumidifier Calculator
https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[56] Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Chapters 7 and 8. Department of Energy (DOE). January 30, 2015, pg 2-12
https://www.regulations.gov/document?D=EERE-2014-BT-STD-0036-0002
[57] Retail Products Platform Product Analysis, Last Updated May 25, 2016.
Available from: https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Building Shell	Air Conditioner – Room (RAC) Cover and Gap Sealer	Residential	5	See note below[58]
	Air Leakage Sealing	Residential	15	GDS[59]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[60]
	Insulation – Opaque Shell	Residential	25	GDS[61]
	Storm Window	Residential	20	DOE[62]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
Domestic Hot Water	Heat Pump Water Heater (HPWH)	Residential	10	DEER 2014 EUL ID: WtrHt-HtPmp
	Indirect Water Heater	Residential	11	DEER 2014 EUL ID: WtrHt-Res-Gas
	Storage Water Heater - Gas	Residential	15	PA Consulting Group[63]
	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	Drain Water Heat Recovery	Residential	30	2019 Title 24[64]
	Low-Flow – Faucet Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Showerhead	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Thermostatic Shower Restriction Valve	Residential	10	UPC[65]

[58] At least one manufacturer's warranty period. www.gss-ee.com/products.html
[59] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[60] Ibid.
[61] Ibid.
[62] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[63] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. Available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[64] 2019 Title 24, Part 6 CASE Report. "Drain Water Heat Recovery – Final Report." Available from: http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_DWHR_Final_September-2017.pdf
[65] UPC certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a. A standard that includes a lifecycle test consisting of 10,000 cycles without fail. 10,000 cycles is the equivalent of three users showering daily for more than nine years.

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner – Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
	Air Conditioner – Room (RAC)	Residential	12	GDS[66]
	Air Conditioner – PTAC	Residential	15	DEER 2014 EUL ID: HVAC-PTAC
	Boiler, Hot Water – Steel Water Tube	Residential	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	Residential	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	Residential	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	Residential	30	ASHRAE Handbook, 2015
	Boiler and Furnace - Combination ("Combi") Boiler	Residential	22	DOE[67]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER[68]
	Duct Sealing and Insulation	Residential	18	DEER 2014 EUL ID: HV-DuctSeal
	Electronically Commutated (EC) Motor – HVAC Blower Fan	Residential	15	DEER 2014 EUL ID: Motors-fan
	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	Residential	15	DEER 2014 EUL ID: Motors-pump
	Furnace, Gas Fired	Residential	22	DOE[69,70]
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP

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

[67] Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces, February 10, 2015, Table 8.2.17. Product definition of furnaces includes electric boilers with firing rates of less than 300,000 BTU/h
Available from: https://energy.mo.gov/sites/energy/files/technical-support-document---residential-furances_doe.pdf

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

[69] 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

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[71]
	Heat Pump – PTHP	Residential	15	DEER 2014 EUL ID: HVAC-PTHP
	Refrigerant Charge Correction & Tune-Up – Air Conditioner and Heat Pump	Residential	10	DEER 2014 EUL ID: HV-RefChrg
	Tune-Up - Boiler	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Tune-Up - Furnace	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Unit Heater, Gas Fired	Residential	13	ASHRAE Handbook, 2015
HVAC - Control	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.)	N/A
	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[72]
	Thermostat – Programmable Setback Thermostat – Wi-Fi (Communicating) Thermostat – Learning	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[73]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[74]

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Lighting	LED Lamp	Residential	Rated Life listed by ENERGY STAR® or default to 15,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Lamps[75]
			50,000 hours	DLC[76]

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

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

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED (Interior)	Residential	Rated Life listed by ENERGY STAR or default to 25,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Fixtures[77]
		LED (Exterior)	Residential	Rated Life listed by ENERGY STAR or default to 35,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Fixtures
		LED (Inseparable)	Residential	Rated Life listed by ENERGY STAR or default to 50,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Fixtures
Lighting Control	Bi-Level Lighting		Multifamily Common Area	15	ComEd[78]

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

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Motors and Drives	Pool Pump	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Other	Pool Heater	Residential	8	DOE[79]

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

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[80]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[81]
	Cooking Equipment[82]	C&I	12	DEER 2014 EUL IDs: Various
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ENERGY STAR®Calc[83]
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
	Refrigerator and Freezer	C&I	12	DEER 2014 EUL ID: Cook-SDRef
Appliance - Control	Advanced Power Strip (APS)	C&I	8	DEER 2014 EUL ID: Plug-OccSens
	Vending Machine and Novelty Cooler Control	C&I	5	DEER 2014 EUL ID: Plug-VendCtrler
Appliance Recycling	Air Conditioner – Room (RAC)	C&I	9	DEER 2014 EUL ID: HV-RAC-ES
Building Shell	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[84]
	Insulation - Opaque Shell	C&I	30	ET & CEC[85]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-WinFilm
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
Compressed Air	Air Compressor	C&I	13	Other State TRMs[86]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[87]

[80] Based on EUL's for similar control technology
[81] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[82] Applicable to all kitchen cooking equipment not otherwise listed
[83] 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
[84] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[85] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[86] 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.
[87] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Compressed Air	No Air Loss Water Drain	C&I	13	MA Measure Life Study C&I Retrofit EUL[88]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [89]
Domestic Hot Water (DHW)	Domestic Hot Water Tank Blanket	C&I	7	DEER
	Heat Pump Water Heater (HPWH)	C&I	10	DEER
	Indirect Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Instantaneous Water Heater	C&I	20	DEER 2014 EUL ID: WtrHt-Instant-Com
	Storage Tank Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
DHW - Control	Low-Flow – Faucet Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Pre-Rinse Spray Valve (PRSV)	C&I	5	GDS
	Low-Flow – Salon Valve	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Low-Flow – Showerhead	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner – PTAC	C&I	15	DEER 2014 EUL ID: HVAC-PTAC
	Air Conditioner – Unitary	C&I	15	DEER 2014 EUL ID: HVAC-airAC
	Boiler and Furnace - Combination ("Combi") Boiler	C&I	22	DOE[90]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER[91]
	Boiler, Hot Water – Steel Water Tube	C&I	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	C&I	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr

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

[89] 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.

[90] Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces, February 10, 2015, Table 8.2.17
Available from: https://energy.mo.gov/sites/energy/files/technical-support-document---residential-furances_doe.pdf

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

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: HVAC-ClTwrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[92]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	Electronically Commutated (EC) Motor - HVAC Blower Fan	C&I	15	DEER 2014 EUL ID: Motors-Fan
	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	C&I	15	DEER 2014 EUL ID: Motors-pump
	Economizer –Dual Enthalpy Air Side	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	Furnace, Gas Fired	C&I	23	DOE[93],[94]
	Heat Pump – Unitary & Applied	C&I	15	DEER 2014 EUL ID: HVAC-airHP
	Heat Pump – PTHP	C&I	15	DEER 2014 EUL ID: HVAC-PTHP
	Heat Pump – Water Source (WSHP)	C&I	25	ASHRAE[95]
	Infrared Heater	C&I	17	GDS[96]
	Refrigerant Charge Correction & Tune Up – Air Conditioner and Heat Pump	C&I	10	DEER 2014 EUL ID: HVAC-RefChg
	Tune-Up - Boiler	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Tune-Up – Chiller System	C&I	5	WI EUL DB[97]
	Variable Refrigerant Flow (VRF) System	C&I	15	DEER 2014 EUL ID: HVAC-VSD-pump
	Unit Heater, Gas Fired	C&I	13	ASHRAE Handbook, 2015

[92] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)
[93] 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
[94] 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
[95] ASHRAE Owning and Operating Cost Database
Available from: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[96] GDS Associates, Inc. "Natural Gas Efficiency Potential Study." DTE Energy. July 29, 2016. Available from: https://www.michigan.gov/documents/mpsc/DTE_2016_NG_ee_potential_study_w_appendices_vFINAL_554360_7.pdf
[97] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
HVAC - Control	Direct Digital Control (DDC) System		C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Demand Control Ventilation (DCV)		C&I	15	DEER 2014 EUL ID: HVAC-VSD-DCV
	Energy Management System		C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Energy Management System – Guest Room		C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Kitchen Demand Ventilation Control		C&I	15	PG&E[98]
	Outdoor Temperature Setback Control for Hydronic Boiler		C&I	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.)	N/A
	Steam Trap – Low-Pressure Space Heating		C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Thermostat – Programmable Thermostat – Wi-Fi (Communicating)		C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve		C&I	15	DOE[99]
Lighting	Light Fixture	LED Fixture (DLC)	C&I	50,000 hours /annual lighting operating hours or 15 yrs if annual operating hours are not known	DLC[100]
		LED Fixture (Interior)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hours/annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®[101]

[98] PG&E Work Paper WPSDGENRCC0019, June 15, 2012
[99] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf
[100] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4
[101] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.1. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED Fixture (Exterior)	C&I	Rated Life listed by ENERGY STAR or default to 35,000 hours/annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®[102]
		LED Fixture (Inseparable)	C&I	Rated Life listed by ENERGY STAR or default to 50,000/annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®[103]
		LED Fixture (Uncertified)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hours /annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	Uncertified
	LED Lamp		C&I	50,000 hours	DLC[104]
				Rated Life listed by ENERGY STAR or default to 15,000 hours /annual lighting operating hours or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR®
	Refrigerated Case LED		C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED

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

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

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

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	Lighting Power Density (LPD)	C&I	15	GDS[105]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[106]
	Integrated Interior Lighting Control	C&I	15	ComEd[107]
	Non-Integrated Interior Lighting Control	C&I	10	GDS[108]
	Plug-Load Occupancy Sensor	C&I	8	DEER[109]
Motors and Drives	Motor	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
	Elevator Modernization	C&I	15	DEER 2014[110]
Other	Pool Heater	C&I	8	DOE[111]
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp

[105] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. As directed in the Interior and Exterior Lighting measure, new construction projects may be evaluated based on LPD. This value is provided for use with new construction LPD projects only.
Available from: https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf
[106] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant
Available from:
http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf
[107] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant
Available from:
http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf
[108] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
Available from: https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf
[109] DEER value for lighting occupancy sensors
[110] Assumes same EUL as VFD measure.
[111] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75 Available from:
https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Refrigeration	Air-Cooled Refrigeration Condenser	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Automatic Door Closer for Walk-In Cooler/Freezer	C&I	8	DEER
	Cooler and Freezer Door Gasket	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	Cooler and Freezer Door Strip	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	Electronically Commutated (EC) Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	Equipment (Condenser, Compressor, and Sub-cooling)	C&I	15	DEER
	Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM)	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	Refrigerated Case Door	C&I	12	DEER 2014 EUL ID: GrocDisp-FixtDoors
	Refrigerated Case Night Cover	C&I	5	DEER 2014 EUL ID: GrocDisp-DispCvrs
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Condenser Pressure and Temperature Control	C&I	15	DEER
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl

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

Record of Revision Number	Issue Date
3-18-21	3/31/2018
6-18-23	6/30/2018
9-18-21	9/30/2018
12-18-17	12/28/2018
3-19-16	3/29/2019
6-19-14	6/30/2019
9-19-10	9/30/2019
12-19-17	12/23/2019

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