Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
12-20-03	A	12/31/2020	12/31/2020	R/MF Adaptive Photonic Control	New Measure Added	Pg. xx
12-20-05	A	12/31/2020	12/31/2020	C/I Electric Deck Oven	New Measure Added	Pg. xx
12-20-07	A	12/31/2020	12/31/2020	C/I Adaptive Photonic Control	New Measure Added	Pg. xx
12-20-08	A	12/31/2020	12/31/2020	C/I Boiler Economizer	New Measure Added	Pg. xx
12-20-11	A	12/31/2020	12/31/2020	C/I Pool Pump	New Measure Added	Pg. xx
12-20-12	R	12/31/2020	12/31/2020	Appendix P	Updated EUL entries for all measures contained in this Record of Revision; Added Common References section	Pg. 996

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between August 12, 2020 – December 31, 2020.

HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

ADAPTIVE PHOTONIC CONTROL FOR HVAC FAN MOTORS

Measure Description

This measure covers the installation of adaptive photonic control systems applied to HVAC fan motors. Adaptive photonic control involves integration with an HVAC system's motors including PTACs, PTHPs, mini-splits, central air units and furnace distribution system supply fans. It enables adaptive speed control for single-speed AC fan motors using sensors by continuously adapting to end-user requirements. The controller uses photonic (opto-electronic) transducers and graphical apertures that are integrated into intelligent, signal and vector processors enabling their use as analog power controllers[1,2]. It provides an adaptive airflow solution by tracking air temperature and optimizing operation based on climate conditions. Savings accrue not only from the reduction of fan speed to match thermal delivery rates, but also through better air mixing in the space and more effective heat transfer on the coils when the system is in operation. By adjusting airflow to improve heat transfer, the controller improves whole system operating efficiency and significantly reduces compressor run times.

This measure is only applicable to adaptive photonic control integrated into single-speed AC induction fan motors rated up to 5 horsepower (HP) that do not have speed variability restriction (e.g., via centrifugal speed switch).[3,4] Savings estimated per this methodology may be claimed in retrofit applications as well as in new construction applications where electronically commutated (EC) motors are not otherwise required by federal, state, local or municipal codes or standards.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{(W_{baseline} \times ESF)}{1{,}000} \times LF \times hrs$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(W_{baseline} \times ESF)}{1{,}000} \times LF \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{(W_{baseline} \times ESF)}{1{,}000} \times LF \times hrs \times HVAC_{ff}$$

[1] IEEE Transactions on Industrial Electronics, 'A novel switched reluctance motor drive with optical graphical programming technology', 2000.
[2] ACHR News, Fan Coil Units Get VSD, 2005
[3] San Diego Gas & Electric, Work Paper WPSDGENRHC1051, Revision 1, Sept 2016
[4] Comfort-Plus Drive™, Variable Speed Drive for Fan Coil Units, 2005

where:

$$W_{baseline} = W_{evaporator} + W_{compressor} + W_{condenser}$$

$$W_{evaporator} = V_{evaporator} \times A_{evaporator} \times PF$$

$$W_{compressor} = V_{compressor} \times A_{compressor} \times PF$$

$$W_{condenser} = V_{condenser} \times A_{condenser} \times PF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
$W_{baseline}$	= Retrofitted system wattage
$W_{evaporator}$	= Retrofitted system evaporator wattage, based on nameplate specifications
$W_{compressor}$	= Retrofitted system compressor wattage, based on nameplate specifications
$W_{condenser}$	= Retrofitted system condenser wattage, based on nameplate specifications
$V_{evaporator}$	= Retrofitted system evaporator voltage
$V_{compressor}$	= Retrofitted system compressor voltage
$V_{condenser}$	= Retrofitted system condenser voltage
$A_{evaporator}$	= Retrofitted system evaporator amps
$A_{compressor}$	= Retrofitted system compressor amps
$A_{condenser}$	= Retrofitted system condenser amps
PF	= Power factor
ESF	= Energy savings factor
LF	= Motor load factor
hrs	= Operating hours
$HVAC_{ff}$	= HVAC interaction factor for annual fuel consumption (MMBtu/kWh)
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
$V_{evaporator}$		From application.
$V_{compressor}$		From application.
$V_{condenser}$		From application.
$A_{evaporator}$		From application.
$A_{compressor}$		From application.
$A_{condenser}$		From application.

Variable	Value	Notes
PF	0.85	From Standard Handbook of Electrical Engineers[5] and the Engineering Toolbox.[6]
ESF	0.30	Average of multiple validation tests.[7]
LF	0.9	Assumed value to reflect that motors do not typically run at 100% of rated power.
hrs		From application. If unknown, see Operating Hours section below.
$HVAC_{ff}$		HVAC interaction factor for annual fuel energy consumption (MMBtu/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[8]

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a single-speed AC induction motor with adaptive photonic control as described in the Measure Description section above in a direct-drive HVAC circulation (blower) fan application.

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.

Effective Useful Life (EUL)

See Appendix P.

[5] Standard Handbook for Electrical Engineers (McGraw-Hill Handbooks), Donald G. Fink, ISBN 10: 0070220050 / ISBN 13: 9780070220058, Published by McGraw-Hill Publishing Co., 1999

[6] Engineering Tool Box, Power Factors for Inductive Loads, https://www.engineeringtoolbox.com/power-factor-electrical-motor-d_654.html

[7] Aclectic, Adaptive Control Technologies, Validation Tests

[8] 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 RM Management Committee.

Ancillary Fossil Fuel Savings Impacts

HVAC circulation fans with adaptive photonic controlled AC 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 with adaptive photonic controlled AC 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.

References

1. A novel switched reluctance motor drive with optical graphical programming technology, Clarkson University, P. Pillay; Yaguang Liu; O.G. Durham, IEEE Transactions on Industrial Electronics (Volume: 47, Issue: 4, Aug 2000).
   Available from: https://ieeexplore.ieee.org/document/857972
2. Fan Coil Units Get VSD, The Air Conditioning, Heating, Refrigeration News, 2005
   Available from: https://www.achrnews.com/articles/95898-fan-coil-units-get-vsd#:~:text=They%20are%20small%20air%2Dhandling,stacked%2C%20or%20installed%20horizontally%20overhead.
3. Guest Room PTAC/PTHP Adaptive Climate Controller, San Diego Gas & Electric, Energy Efficiency Engineering, Work Paper WPSDGENRHC1051, Revision 1, Sept 2016.
   Available from: http://www.deeresources.net/workpapers
4. Comfort-Plus Drive™, Variable Speed Drive for Fan Coil Units, Carrier Corporation, 2005
   Available from: https://dms.hvacpartners.com/docs/1003/Public/08/05-02-0501-01.pdf
5. Standard Handbook for Electrical Engineers (McGraw-Hill Handbooks), Donald G. Fink, ISBN 10: 0070220050 / ISBN 13: 9780070220058, Published by McGraw-Hill Publishing Co., 1999
6. Engineering Tool Box, Power Factors for Inductive Loads
   Available from: https://www.engineeringtoolbox.com/power-factor-electrical-motor-d_654.html
7. Multiple Validation Tests of Adaptive Photonic Technology Controller at (1) ConEdison, (2) Environmental Test Laboratory, (3) EME Consulting Engineers (NYSERDA), (4) SUNY Oneonta, (5) Tim Garrison (Third Party), (6) McQuay Cooling Tests, (7) Purdue University Tests and (8) ConEdison Tests by ERS.
   Available from: https://efbb029c-a900-4301-9ab1-40fc00b9e54e.filesusr.com/ugd/9cd7aa_186d85d0a69b4da4b69f07ea0d03eeff.pdf?index=true
8. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps

Record of Revision

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12-20-3	12-31-2020

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APPLIANCE

ELECTRIC DECK OVEN

Measure Description

This measure covers the installation of efficient electric deck ovens. Commercial deck ovens cook food directly placed on the floor of a heater chamber. The bottom of each compartment is called a deck and heat is typically supplied by burners or elements located beneath the deck. The oven ceiling, floor, and walls are designed to absorb heat quickly and radiate that heat back slowly and evenly.[9] Deck ovens are available in various sizes measured by the surface area of the oven cavity floor. Sizes range from approximately 1,000 in^2 to 2,200 in^2. Deck ovens are typically stackable to allow for multiple ovens on a single floor space.[10]

Qualifying deck ovens must be rated according to ASTM Standard Test Method for Performance of Deck Ovens F1965-99,[11] and must meet or exceed a minimum of 60% cooking efficiency.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

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

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

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

[9] ENERGY STAR Program requirements for Commercial ovens, Version 2.2
[10] Cal TF Workpaper SWFS009-01 Revision 1, pg 2.
[11] American Society for Testing and Materials (ASTM). 2010. ASTM F1965-17, Standard Test Method for the Performance of Deck Ovens, West Conshohocken, PA: ASTM International.

NOTE: $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms can be calculated per the equations above using any combination of actual qualifying equipment specifications and assumed values as defined in the Baseline Efficiencies, Compliance Efficiency and Operating Hours sections below, or looked up from the Default Values table below.

where:

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
$\Delta MMBtu$ = Annual fuel energy savings
$\Delta BTU_{preheat}$ = Daily preheat energy savings
ΔBTU_{idle} = Daily idle energy savings
$\Delta BTU_{cooking}$ = Daily cooking energy savings
units = Number of units installed
days = Operating days per year
hrs = Daily operating hours
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
$BTU_{preheat}$ = Equipment preheat energy (BTU)
$N_{preheat}$ = Number of preheats per day
$hrs_{preheat}$ = Preheat duration (hours)
BTU/h_{idle} = Equipment idle energy rate (BTU/h)
lbs/hr = Equipment production capacity (lbs/hr)
lbs = Total daily food production
Q_{food} = Heat to food (BTU/lb)
Eff = Equipment convection/steam mode cooking efficiency
CF = Coincidence factor
3,412 = Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta BTU_{preheat}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{idle,}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking}$		Calculate based on calculations above or look up in Default Values table below.
days		From application or look up based on facility type in Operating Hours section below.
hrs		From application or look up based on facility type in Operating Hours section below.
$N_{preheat}$	1	California Technical Forum Workpaper. [12]
$BTU_{preheat,baseline}$		Look up in Baseline Efficiencies section below.
$BTU_{preheat,ee}$		From application or look up in Compliance Efficiency section below.

[12] Cal TF Workpaper SWFS009-01 Revision 1, pg. 8

Variable	Value	Notes
$BTU/h_{idle,baseline}$		Look up in Baseline Efficiencies section below.
$BTU/h_{idle,ee}$		From application or look up in Compliance Efficiency section below
$hrs_{preheat}$	0.50	California Technical Forum[13]
lbs	200	From application or use value provided.[14]
lbs/hr		From application. If unknown, use 60 as default.
$Eff_{,baseline}$		Look up in Baseline Efficiencies section below.
Eff_{ee}		From application or look up in Compliance Efficiency section below.
Q_{food}	250	Heat to food (BTU/lb)[15]
CF	0.9	

Default Values

The table below contains values and simplified calculations for $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms that may be used in the formulation of estimated savings in lieu of utilizing the calculations prescribed above for these terms. These values were established by performing those calculations using assumed values from the Summary of Variables and Data Sources above and Baseline Efficiencies and Compliance Efficiency sections below.

Equipment	$\Delta BTU_{preheat}$	ΔBTU_{idle}	$\Delta BTU_{cooking}$
Deck Oven, Electric	11,942	2,047 x hrs – 7,848	41,667

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[16]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is an electric oven as defined in the Measure Description section above with operating characteristics per the table below.[17]

Equipment	$BTU_{preheat,baseline}$ (BTU)	$BTU/h_{idle,baseline}$ (BTU/h)	lbs/hr	$Eff_{baseline}$
Deck Oven, Electric	22,178	6,483	60	0.40

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an electric deck oven meeting or exceeding a minimum of 60% cooking efficiency. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the table below. Performance specifications are as reported from the referenced California Technical Forum workpaper.[18]

[13] Ibid, pg. 8
[14] Ibid, pg. 8
[15] Ibid, pg. 8
[16] Ibid, pg. 9
[17] Ibid, pg. 3
[18] Cal TF workpaper SWFS009-01, pg. 3

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	lbs/hr	Eff_{ee}
Deck Oven, Electric	10,236	4,436	60	0.60

Operating Hours

Equipment operating hours per day and days per year shall be taken from the application if known. Default operating hours per day and days per year are provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[19]

Facility Type	Hours/Day	Days/Year
Community College	11	283
Fast Food	14	363
Full Service Restaurant	12	321
Grocery	12	365
Hospital	11	365
Hotel	20	365
Miscellaneous	9	325
Motel	20	365
Primary School	5	180
Secondary School	8	180
Small Office	12	250
University	11	283

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the condition space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

Ancillary Electric Savings Impacts

More efficient food service equipment rejects less heat into the condition space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

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

References

1. ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 2.2, October 2015
   Available from:
   https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ovens/partners
2. California Technical Forum, Workpaper SWFS009-01, January 2020
   Available from: deeresources.net/workpapers
3. American Society for Testing and Materials (ASTM). 2010. ASTM F1965-17, Standard Test Method for the Performance of Deck Ovens, West Conshohocken, PA: ASTM International
4. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014

Record of Revision

Record of Revision Number	Issue Date
12-20-5	12/31/2020

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

ADAPTIVE PHOTONIC CONTROL FOR HVAC FAN MOTORS

Measure Description

This measure covers the installation of adaptive photonic control systems applied to HVAC fan motors. Adaptive photonic control involves integration with an HVAC system's motors including PTACs, PTHPs, mini-splits, central air units and furnace distribution system supply fans. It enables adaptive speed control for single-speed AC fan motors using sensors by continuously adapting to end-user requirements. The controller uses photonic (opto-electronic) transducers and graphical apertures that are integrated into intelligent, signal and vector processors enabling their use as analog power controllers[20,21]. It provides an adaptive airflow solution by tracking air temperature and optimizing operation based on climate conditions. Savings accrue not only from the reduction of fan speed to match thermal delivery rates, but also through better air mixing in the space and more effective heat transfer on the coils when the system is in operation. By adjusting airflow to improve heat transfer, the controller improves whole system operating efficiency and significantly reduces compressor run times.

This measure is only applicable to adaptive photonic control integrated into single-speed AC induction fan motors rated up to 5 horsepower (HP) that do not have speed variability restriction (e.g., via centrifugal speed switch).[22,23] Savings estimated per this methodology may be claimed in retrofit applications as well as in new construction applications where electronically commutated (EC) motors are not otherwise required by federal, state, local or municipal codes or standards.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{(W_{baseline} \times ESF)}{1{,}000} \times LF \times hrs$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(W_{baseline} \times ESF)}{1{,}000} \times LF \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{(W_{baseline} \times ESF)}{1{,}000} \times LF \times hrs \times HVAC_{ff}$$

[20] IEEE Transactions on Industrial Electronics, 'A novel switched reluctance motor drive with optical graphical programming technology', 2000.
[21] ACHR News, Fan Coil Units Get VSD, 2005
[22] San Diego Gas & Electric, Work Paper WPSDGENRHC1051, Revision 1, Sept 2016
[23] Comfort-Plus Drive™, Variable Speed Drive for Fan Coil Units, 2005

where:

$$W_{baseline} = W_{evaporator} + W_{compressor} + W_{condenser}$$

$$W_{evaporator} = V_{evaporator} \times A_{evaporator} \times PF$$

$$W_{compressor} = V_{compressor} \times A_{compressor} \times PF$$

$$W_{condenser} = V_{condenser} \times A_{condenser} \times PF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
$W_{baseline}$	= Retrofitted system wattage
$W_{evaporator}$	= Retrofitted system evaporator wattage, based on nameplate specifications
$W_{compressor}$	= Retrofitted system compressor wattage, based on nameplate specifications
$W_{condenser}$	= Retrofitted system condenser wattage, based on nameplate specifications
$V_{evaporator}$	= Retrofitted system evaporator voltage
$V_{compressor}$	= Retrofitted system compressor voltage
$V_{condenser}$	= Retrofitted system condenser voltage
$A_{evaporator}$	= Retrofitted system evaporator amps
$A_{compressor}$	= Retrofitted system compressor amps
$A_{condenser}$	= Retrofitted system condenser amps
PF	= Power factor
ESF	= Energy savings factor
LF	= Motor load factor
hrs	= Operating hours
$HVAC_{ff}$	= HVAC interaction factor for annual fuel consumption (MMBtu/kWh)
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
$V_{evaporator}$		From application.
$V_{compressor}$		From application.
$V_{condenser}$		From application.
$A_{evaporator}$		From application.
$A_{compressor}$		From application.
$A_{condenser}$		From application.

Variable	Value	Notes
PF	0.85	From Standard Handbook of Electrical Engineers[24] and the Engineering Toolbox.[25]
ESF	0.30	Average of multiple validation tests.[26]
LF	0.9	Assumed value to reflect that motors do not typically run at 100% of rated power.
hrs		From application. If unknown, see Operating Hours section below.
$HVAC_{ff}$		HVAC interaction factor for annual fuel energy consumption (MMBtu/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[27]

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a single-speed AC induction motor with adaptive photonic control as described in the Measure Description section above in a direct-drive HVAC circulation (blower) fan application.

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)	HVAC Int	Facility Type	Hours (hrs/yr)	HVAC Int
Auto Related*	2,810	AR	Manufacturing Facility	2,857	Ind
Automotive / Transportation Service or Repair Facility (24/7)	8,760	AR	Medical Offices	3,748	SOfc
Bakery	2,854	FS	Motion Picture Theatre	1,954	Asy
Banks	3,748	SOfc	Multi-Family (Common Areas)	7,665	MFL

[24] Standard Handbook for Electrical Engineers (McGraw-Hill Handbooks), Donald G. Fink, ISBN 10: 0070220050 / ISBN 13: 9780070220058, Published by McGraw-Hill Publishing Co., 1999

[25] Engineering Tool Box, Power Factors for Inductive Loads, https://www.engineeringtoolbox.com/power-factor-electrical-motor-d_654.html

[26] Aclectic, Adaptive Control Technologies, Validation Tests

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

Facility Type	Hours (hrs/yr)	HVAC Int	Facility Type	Hours (hrs/yr)	HVAC Int
Church	1,955	Rel	Museum	3,748	Asy
College – Cafeteria**	2,713	FS	Nursing Homes	5,840	MFL
College – Classes	2,586	CC	Office (General Office Types)**	3,013	SOfc/ LOfc
College - Dormitory	3,066	Dorm	Parking Garages	4,368	None
Commercial Condos***	3,100	SOfc	Parking Garages (24/7)	7,717	None
Convenience Stores	6,376	SRet	Parking Lots	4,100	None
Convention Center	1,954	Asy	Penitentiary	5,477	MFL
Court House	3,748	LOfc	Performing Arts Theatre	2,586	Asy
Dining: Bar Lounge/Leisure	4,182	FS	Police / Fire Stations (24 Hr)	7,665	Asy
Dining: Cafeteria / Fast Food	6,456	FF	Post Office	3,748	SRet
Dining: Family	4,182	FS	Pump Stations	1,949	Ind
Entertainment	1,952	Asy	Refrigerated Warehouse	2,602	RWH
Exercise Center	5,836	SRet	Religious Building	1,955	Rel
Fast Food Restaurants	6,376	FF	Restaurants	4,182	FS
Fire Station (Unmanned)	1,953	Asy	Retail	3,463	SRet/ LRet
Food Stores	4,055	Gro	School / University	2,187	Univ
Gymnasium	2,586	Asy	Schools (Jr./Sr. High)	2,187	HS
Hospitals	7,674	Hosp	Schools (Preschool/Elementary)	2,187	Sch
Hospitals / Health Care	7,666	Hosp	Schools (Technical/Vocational)	2,187	CC
Industrial - 1 Shift	2,857	Ind	Small Services	3,750	SOfc
Industrial - 2 Shift	4,730	Ind	Sports Arena	1,954	Asy
Industrial - 3 Shift	6,631	Ind	Town Hall	3,748	Asy
Laundromats	4,056	SRet	Transportation	6,456	Asy
Library	3,748	LOfc	Warehouse (Not Refrigerated)	2,602	WH
Light Manufacturers**	2,613	Ind	Waste Water Treatment Plant	6,631	Ind
Lodging (Hotels/Motels)	3,064	Hotel/ Motel	Workshop	3,750	Ind
Mall Concourse	4,833	LRet			

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

HVAC circulation fans with adaptive photonic controlled AC 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 with adaptive photonic controlled AC 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.

References

1. A novel switched reluctance motor drive with optical graphical programming technology, Clarkson University, P. Pillay; Yaguang Liu; O.G. Durham, IEEE Transactions on Industrial Electronics (Volume: 47, Issue: 4, Aug 2000).
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   Available from: https://www.achrnews.com/articles/95898-fan-coil-units-get-vsd#:~:text=They%20are%20small%20air%2Dhandling,stacked%2C%20or%20installed%20horizontally%20overhead.
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   Available from: http://www.deeresources.net/workpapers
4. Comfort-Plus Drive™, Variable Speed Drive for Fan Coil Units, Carrier Corporation, 2005
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5. Standard Handbook for Electrical Engineers (McGraw-Hill Handbooks), Donald G. Fink, ISBN 10: 0070220050 / ISBN 13: 9780070220058, Published by McGraw-Hill Publishing Co., 1999
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   Available from: https://www.engineeringtoolbox.com/power-factor-electrical-motor-d_654.html
7. Multiple Validation Tests of Adaptive Photonic Technology Controller at (1) ConEdison, (2) Environmental Test Laboratory, (3) EME Consulting Engineers (NYSERDA), (4) SUNY Oneonta, (5) Tim Garrison (Third Party), (6) McQuay Cooling Tests, (7) Purdue University Tests and (8) ConEdison Tests by ERS.
   Available from: https://efbb029c-a900-4301-9ab1-40fc00b9e54e.filesusr.com/ugd/9cd7aa_186d85d0a69b4da4b69f07ea0d03eeff.pdf?index=true

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

BOILER ECONOMIZER

Measure Description

This measure covers the installation of a boiler economizer. Also known as stack economizers and feedwater economizers, boiler economizers are designed to recover heat from hot flue gases. Recovered heat is used to pre-heat boiler feedwater, reducing heating requirements. Condensing and conventional economizers are the two principal types of boiler economizers. Conventional, or non-condensing economizers are typically air-to-water heat exchangers and operate above the dew point of the flue gas to avoid condensation.[28] Condensing economizers are designed to allow condensing of the exhaust gas components and reduce the flue gas temperature below its dew point. Condensing economizers recapture latent heat, resulting in improved effectiveness of waste heat recovery.[29] This measure is applicable to the installation of condensing and non-condensing economizers on boilers serving space heating loads and process loads and is restricted to non-condensing, forced draft burner boilers.

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 Fuel Energy Savings

$$\Delta MMBtu = units \times (kBTU/h_{in})/unit \times \frac{ESF \times hrs}{1{,}000}$$

where:

$$ESF = \frac{(T_{baseline} - T_{ee})}{40} \times TRE$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
$(kBTU/h_{in})/unit$	= Fuel input rating per boiler, based on nameplate data
ESF	= Energy Savings Factor[30]

[28] US DOE, Improving Steam System Performance: A Sourcebook for Industry, Second Edition
[29] US DOE, Steam Tip Sheet #26B, Considerations When Selecting a Condensing Economizer
[30] US DOE, Steam Tip Sheet #3, Use Feedwater Economizers for Waste Heat Recovery

hrs = System full load operating hours (see Summary of Variables and Data Sources for details)
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
T = Full-fire boiler flue gas temperature as it exits the stack, in ºF
TRE = Temperature Reduction Efficiency; percentage efficiency increases for stack temperature reduction, per 40ºF reduction in net stack temperature
40 = Stepped reduction in net stack temperature, in ºF
1,000 = Conversion factor, one MMBTU equals to 1,000 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
(kBTU/h_{in})/unit		Nominal heating input capacity is the nameplate input rating of the unit in kBTU/h, from application.
$T_{baseline}$		From application. If unknown, use a default of 420ºF for hot water boilers and 500ºF for steam boilers.[31]
T_{ee}		From application. If unknown, lookup from the Compliance Efficiency section below based on boiler and economizer.
TRE		From application. If unknown, use default of 0.01.[32]
hrs		For space heating boilers, use $EFLH_{heating}$, lookup based on building type and location in Appendix G. For process loads, input value from application.

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a non-condensing, forced draft burner boiler serving space heating or process loads without a stack economizer.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a non-condensing, forced draft burner boiler serving space heating or process loads with a non-condensing or condensing stack economizer.

[31] Assumes hot water boiler efficiency of 82% and steam boiler efficiency of 80% based on ECCCNYS 2020, Table C403.3.2(5)
[32] US DOE, Steam Tip Sheet #3, Use Feedwater Economizers for Waste Heat Recovery

Equipment Type	Energy Efficient Boiler Flue Gas Temperature (T_{ee})	
	Conventional Economizer[33,34]	Condensing Economizer[35,36]
Hot Water Boiler	335°F	247.5°F
Steam Boiler	375°F	287.5°F

Operating Hours

For boilers serving space heating loads, equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type and location can be found in Appendix G.

For boilers serving process loads, operating hours shall come from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

References

1. U.S. Department of Energy, Energy Efficiency and Renewable Energy. Improving Steam System Performance: A Sourcebook for Industry, Second Edition. October 2012. Available from: https://www.nrel.gov/docs/fy13osti/51710.pdf
2. U.S. Department of Energy, Energy Efficiency and Renewable Energy. Steam Tip Sheet #26A, *Consider Installing a Condensing Economizer*. January 2012. Available from: https://www.energy.gov/sites/prod/files/2014/05/f16/steam26a_condensing.pdf
3. U.S. Department of Energy, Energy Efficiency and Renewable Energy. Steam Tip Sheet #26B, *Considerations when Selecting a Condensing Economizer*. January 2012. Available from: https://www.energy.gov/sites/prod/files/2014/05/f16/steam26b_condensing.pdf

[33] As cited in U.S. DOE, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer, the minimum stack temperature for a non-condensing economizer is 250°F. The average temperature drop is assumed to be halfway between the baseline and efficient temperature minimum: (420°F + 250°F) / 2 = 335°F
[34] Ibid, the minimum stack temperature for a non-condensing economizer is 250°F: (500°F + 250°F) / 2 = 375°F
[35] Ibid, the minimum stack temperature for a condensing economizer is 75°F: (420°F + 75°F) / 2 = 247.5°F
[36] Ibid, the minimum stack temperature for a condensing economizer is 75°F: (500°F + 75°F) / 2 = 287.5°F

4. U.S. Department of Energy, Energy Efficiency and Renewable Energy. Steam Tip Sheet #3, *Use Feedwater Economizers for Waste Heat Recovery*. January 2012. Available from: https://www.energy.gov/sites/prod/files/2014/05/f16/steam3_recovery.pdf
5. ECCCNYS 2020 Table C403.3.2(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers & Table C404.2: Minimum Performance of Water Heating Equipment Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency

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MOTORS AND DRIVES

POOL PUMP

Measure Description

This measure covers the installation of ENERGY STAR® qualified multi-speed and variable frequency drive (VFD) commercial inground pool pumps. Pool pump speeds vary based on the pump's operation. Filtration, for example, only requires half the flow rate of running a pool cleaner. Conventional pool pumps, with only one speed, are set to run at the higher speeds required of the pool cleaner and waste energy during filtration operation by running faster than necessary. An ENERGY STAR® certified pool pump can run at different speeds and be programmed to match the pool operation with its appropriate pool pump speed. The energy saved is considerable; reducing pump speed by one-half allows the pump to use just one-eighth as much energy.[37] After January 1, 2019, all pool pumps must be rated according to Weighted Energy Factor (WEF).[38] Pool pumps that have earned this label use up to 70% less energy than non-qualified models.[39]

This measure is applicable to multi-speed and VFD inground or self-priming pool pumps with a total horsepower rating between 1 and 3 HP. While single-speed pumps, non-self-priming pumps, and pressure cleanser booster pumps are eligible under ENERGY STAR® qualified product criteria, there was a critical lack of information regarding ENERGY STAR® calculations and assumptions pertaining to this equipment available at the time of publication of this measure. The measure scope will be expanded as more information becomes available. This measure is applicable to all pool facilities except those that fall under the NY health code Subpart 6-1: a single-family swimming pool, or other bathing facility, a spa pool or a floating tank.[40]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{days}{1{,}000} \times V_{pool} \times N_{turnover} \times \left[\frac{1}{EF_{baseline}} - \frac{1}{WEF_{ee}}\right]$$

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

Note- Although pump hp is not applied directly within algorithms, it must be known to establish baseline and compliance efficiency values.

[37] ENERGY STAR® Pool Pumps
[38] ENERGY STAR® Pool Pumps Version 2 and Version 3 Specification Cover Letter, April 2018
[39] ENERGY STAR® Pool Pump Fact Sheet, January 2018
[40] SubPart6-1.3, Swimming pools, NewYork Codes, Rules and Regulations

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
days	= Number of operating days per year
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
WEF	= Weighted Energy factor (kgal/kWh)
EF	= Energy factor (kgal/kWh)
V_{pool}	= Volume of pool, in gallons
$N_{turnover}$	= Number of turnovers per day, where a turnover is a full cycling of pool water through the pool filter
hp	= Horsepower of qualifying pump motor
1,000	= Conversion factor, one kgal equals 1,000 gallons

Summary of Variables and Data Sources

Variable	Value	Notes
V_{pool}		From application. If unknown, assume 22,400.[41]
$N_{turnover}$		From application. If unknown, use 4 per day. [42]
WEF_{ee}		From application, or look up in Compliance Efficiency section below, based on nameplate hp.
hp		From application.
$EF_{baseline}$		Look up in Baseline Efficiencies section below, based on nameplate hp.
days		From application.
hrs_{annual}		From application.

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 non-ENERGY STAR® qualified single-speed pool pump. The values for baseline EF are found in the table below, based on nameplate horsepower. Pump Performance Curve C is assumed for pool pumps. The pump curve compares the total head in feet of water to the flow rate of the water for a given pump at a given motor speed.

Pump Type and Variable	Nameplate Horsepower						
	0.5	0.75	1	1.5	2	2.5	3
$EF_{baseline}$	3.4	3.3	2.5	2.3	2.3	2.2	2.0

[41] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 7/14/2020)
[42] SubPart6-1.11 Treatment, Swimming pools, NewYork Codes, Rules and Regulations

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified multi or variable speed self-priming, inground pool pump. Self-priming pool pumps must have a WEF (in kgal/kWh) equal to or greater than the equation below for pumps on curve C.[43]

$$WEF \geq -230 \times ln(hhp) + 6.59$$

where:
hhp = hydraulic horsepower, equal to or greater than 0.711

Multi-Speed and Variable Frequency Drive Pool Pumps[44]
Typical WEF for ENERGY STAR® multi-speed and variable frequency drive pool pumps are found in the table below, based on nameplate horsepower. Pump Performance Curve C is assumed for ENERGY STAR pumps. The pump curve compares the total head in feet of water to the flow rate of the water for a given pump at a given motor speed.

Pump Type and Variable	Nameplate Horsepower at High Speed				
	1-1.4 HP (0.72 hhp)	1.65 HP (0.95 hhp)	2 HP (1.18 hhp)	2.5 HP (1.25 hhp)	3 HP (1.65 hhp)
WEF_{ee}	8.7	8.9	9.3	7.4	7.1

Operating Hours

The annual operating days shall be taken from application. While in use, the energy efficient pump cycles through pool water at a default rate of 6 hours per turnover as mandated by the NY Codes and Regulations.[45]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary fossil fuel savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

Ancillary Electric Savings Impacts

Ancillary electric savings impacts, if appropriate, will be researched and incorporated into this measure algorithm in future revisions to the TRM.

[43] ENERGY STAR® Program Requirements Product Specification for Pool Pumps, Eligibility Criteria Version 2.0, January 2019
[44] Ibid
[45] Subpart6-1.11 Treatment, Swimming pools, NewYork Codes, Rules and Regulations

References

1. ENERGY STAR® Program Requirements Product Specification for Pool Pumps, Eligibility Criteria Version 2.0, January 2019
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%202.0%20Pool%20Pumps%20Specification.pdf
2. SubPart6-1, Swimming pools, NewYork Codes, Rules and Regulations
   Available from: https://regs.health.ny.gov/content/subpart-6-1-swimming-pools
3. 10 CFR Appendix B to Subpart Y of Part 431 – Uniform Test Method for the Measurement of Energy Efficiency of Dedicated-Purpose Pool Pumps
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=1e172a51fbd7c0fa1753866066133e14&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1466.b

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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[46]
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[47]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[48]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[49]
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[50]
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

[46] 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

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

[48] ENERGY STAR® Dehumidifier Calculator https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls

[49] 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

[50] 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[51]
	Air Leakage Sealing	Residential	15	GDS[52]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[53]
	Insulation – Opaque Shell	Residential	25	GDS[54]
	Storm Window	Residential	20	DOE[55]
	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[56]
	Storage Water Heater - Electric	Residential	13	DEER 2014 EUL ID: WtrHt-Res-Elec
	Instantaneous Water Heater	Residential	20	DEER 2014 EUL ID: WtrHt-Instant-Res
	Solar Pool Heater	Residential	15	DOE[57]
Domestic Hot Water - Control	Drain Water Heat Recovery	Residential	30	2019 Title 24[58]
	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[59]

[51] At least one manufacturer's warranty period. www.gss-ee.com/products.html
[52] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[53] Ibid.
[54] Ibid.
[55] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[56] 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
[57] https://www.energy.gov/energysaver/solar-swimming-pool-heaters
[58] 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
[59] 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[60]
	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[61]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER 2014[62] EUL ID: HVAC-Frnc
	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
	Energy and Heat Recovery Ventilator	Residential	14	PA Consulting Group[63]

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

[61] 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

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

[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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Furnace, Gas Fired	Residential	22	DOE[64],65
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[66]
	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	Adaptive Photonic Control	Residential	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A
	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[67]
	Thermostat – All Types	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats

[64] 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

[65] 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

[66] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

[67] NYSERDA Residential Electric Submetering Manual

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
HVAC - Control	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[68]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[69]
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[70]
			50,000 hours	DLC[71]

[68] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. pg. 16
[69] Based on assumed EUL of integrated fan, which is expected to be the first component to fail
[70] 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
[71] 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[72]
		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[73]

[72] 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

[73] 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
	Pool Circulator Timer	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Other	Pool Heater	Residential	8	DOE[74]

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

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment	High Speed Fans	C&I	10	PG&E[75]
	Milk Pre-Cooler Heat Exchanger	C&I	15	PA Consulting Group[76]
	Refrigeration Heat Recovery	C&I	14	DEER 2014 EUL ID: HVAC-ChlrComp-Ag
	Scroll Compressor	C&I	12	DEER 2014 EUL ID: RefgWrhs-ScrollComp
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[77]
	Variable Speed Drive Milk Pump Plate Cooler	C&I	15	PA Consulting Group[78]
	Variable Speed Drive Vacuum Pump	C&I	15	PA Consulting Group[79]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[80]
	Cooking Equipment[81]	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[82]
	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

[75] PG&E Work Paper PGE3PAGR117, October 12, 2017
[76] 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
[77] Based on EUL's for Advanced Power Strips
[78] 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
[79] 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
[80] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[81] Applicable to all kitchen cooking equipment not otherwise listed
[82] 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

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Building Shell	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[83]
	Insulation - Opaque Shell	C&I	30	ET & CEC[84]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-WinFilm
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
	Air Curtains	C&I	15	DEER 2014 EUL ID: Motors-fan
Compressed Air	Air Compressor	C&I	13	Other State TRMs[85]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[86]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study[87]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [88]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [89]
	Flow Controller	C&I	13	Other State TRMs [90]
	Low Pressure Drop Filter	C&I	5	Other State TRMs [91]
Domestic Hot Water (DHW)	Heat Pump Water Heater (HPWH)	C&I	10	DEER EUL ID: WtrHt-HtPmp
	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

[83] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[84] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[85] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (December 2018). Estimates range from 10 to 15 years.
[86] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[87] 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
[88] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (December 2018). Estimates range from 10 to 15 years.
[89] Ibid.
[90] Ibid.
[91] Ibid.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
DHW - Control	Low-Flow – Showerhead	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Central DHW Control	C&I	15	NREL[92]
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[93]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER 2014[94] EUL ID: HVAC-Frnc
	Boiler, Hot Water – Steel Water Tube	C&I	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	C&I	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: HVAC-ClTwrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[95]
	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

[92] https://www.nrel.gov/docs/fy16osti/64541.pdf
[93] 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
[94] Based on DEER value for high efficiency boiler and instantaneous water heater
[95] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Furnace, Gas Fired	C&I	23	DOE[96],97
	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[98]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[99]
	Infrared Heater	C&I	17	GDS[100]
	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[101]
	Tune-Up – Furnace	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Variable Refrigerant Flow (VRF) System	C&I	15	DEER 2014 EUL ID: HVAC-VSD-pump
	Unit Heater, Gas Fired	C&I	13	ASHRAE Handbook, 2015
HVAC – Control	Adaptive Photonic Control	C&I	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	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

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

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

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

[99] 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

[100] 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

[101] 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	Energy Management System – Guest Room	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Boiler Economizer	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	GDS[102]
	Kitchen Demand Ventilation Control	C&I	15	PG&E[103]
	Outdoor Temperature Setback Control for Hydronic Boiler	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	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[104]
	Advanced Rooftop Control	C&I	EUL = RUL of Existing RTU = RTU EUL – (Current Year – Year of Mfr.) **Default = 5**	N/A

[102] Natural Gas Energy Efficiency Potential in Massachusetts, GDS Associates, 2009. Available from: http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
[103] PG&E Work Paper WPSDGENRCC0019, June 15, 2012
[104] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED Fixture (DLC)	C&I	50,000 hrs /annual lighting operating hrs or 15 yrs if annual operating hrs are not known	DLC[105]
		LED Fixture (Interior)	C&I	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 hrs are not known	ENERGY STAR®106
		LED Fixture (Exterior)	C&I	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 hrs are not known	ENERGY STAR®107
		LED Fixture (Inseparable)	C&I	Rated Life listed by ENERGY STAR or default to 50,000/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®108
		LED Fixture (Uncertified)	C&I	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 hrs are not known	Uncertified

[105] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4

[106] 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

[107] 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

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

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	LED Lamp	C&I	50,000 hours	DLC[109]
			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 hrs are not known	ENERGY STAR®
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
	Lighting Power Density (LPD)	C&I	15	GDS[110]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[111]
	Integrated Interior Lighting Control	C&I	15	ComEd[112]
	Non-Integrated Interior Lighting Control	C&I	10	GDS[113]
	Plug-Load Occupancy Sensor	C&I	8	DEER[114]
Motors and Drives	Motor	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Notched & Synchronous Belt	C&I	5	DEER 2014 EUL ID: HV-CoggedBelt
	Pool Pump	C&I	10	DEER 2014 EUL ID: OutD-PoolPump
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
	Elevator Modernization	C&I	15	DEER 2014[115]

[109] 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

[110] 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

[111] 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

[112] 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

[113] 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

[114] DEER value for lighting occupancy sensors

[115] Assumes same EUL as VFD measure.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Other	Pool Heater	C&I	8	DOE[116]
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Ozone Laundry	C&I	10	PG&E[117]
	Process Exhaust Filtration	C&I	15	CIBSE[118]
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 2014 EUL ID: GrocWlkIn-DrClsr
	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 2014 EUL ID: GrocSys-MechSubcl
	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 2014 EUL ID: GrocSys-Cndsr
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Floating Head Pressure Control	C&I	10	PA Consulting Group [119]

[116] 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

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

[118] Chartered Institution of Building Services Engineers. "Probabilistic Estimation of Service Life." An industrial ventilation system consists of a fan and a set of filters; Fan and Filter EUL are 15 to 20 years depending on type. http://www.cibse.org/knowledge/cibse-technical-symposium-2011/probabilistic-estimation-of-service-life.

[119] PA Consulting Group Inc. "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report." August 25, 2009. https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

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2. GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures Available from:
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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
6-18-23	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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