Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
7-21-03	R	08/30/2021	1/1/2022	R/MF Air Conditioner – Room (RAC) Cover and Gap Sealer	Added language to Measure Description to clarify applicability of measure to permanently installed RACs	Pg. 52
7-21-05	R	08/30/2021	1/1/2022	R/MF Insulation – Opaque Shell	Combined measure (7-21-04) Residential Insulation – Opaque Shell into R/MF Insulation – Opaque Shell. Added baseline defaults for uninsulated walls and ceilings. Revised savings estimation methodology	Pg. 71
7-21-07	R	08/30/2021	1/1/2022	R/MF Heat Pump Water Heater	Added language to Measure Description detailing direction for baseline assumptions for new construction/major renovation; Added baseline heating efficiency default options; Added electric demand penalty option	Pg. 90
7-21-09	R	08/30/2021	1/1/2022	R/MF Interior and Exterior Lighting	Modified Baseline Efficiencies lumen bins to eliminate gaps	Pg. 266
7-21-11	R	08/30/2021	1/1/2022	R/MF Solar Pool Heater	Measure Description expanded to include multiple solar heating technologies; Updated Annual Fossil Fuel Energy Savings algorithm.	Pg. 285
7-21-12	R	08/30/2021	1/1/2022	C/I High Speed Fan	Added detail specifying application of algorithm to include all fan types; Updated Baseline Efficiencies and Compliance Efficiencies defaults to include all fan types under CFM/W; Updated operating hours for exhaust/ventilation fans.	Pg. 290
7-21-15	R	08/30/2021	08/30/2021	C/I High Volume Low Speed Fan	Revised savings estimation methodology, variables terms, definitions, and default tables to reflect lbf/kW.	Pg. 558
7-21-16	C	08/30/2021	08/30/2021	C/I Advanced RTU Control	Updated algorithm, terms, and variables to include electric heating impacts; Revised fan control energy savings factor; Updated unit energy savings tables; Moved compliance detail from Measure Description to Compliance Efficiency	Pg. 584

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
7-21-20	R	08/30/2021	1/1/2022	C/I EC Motor – Refrigerated Case or Walk-in	Revised language in the Summary of Variables and Data Sources table to allow COP values to come from application when manufacture/nameplate data is missing	Pg. 691
7-21-21	R	08/30/2021	1/1/2022	Appendix P	Updated EUL entries for all measures in this Record of Revision	Pg. 996
7-21-22	R	08/30/2021	1/1/2022	R/MF Low-Flow Showerhead	Added baseline assumption for LMI application; Updated person per household to allow from application	Pg. 128
7-21-23	C	08/30/2021	08/30/2021	R/MF Thermostatic Radiator Valve (TRV) – one Pipe Steam Radiator	Corrected deemed average fuel savings	Pg. 258

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between April 30, 2021 – August 30, 2021.

BUILDING SHELL

AIR CONDITIONER – ROOM (RAC) COVER AND GAP SEALER

Measure Description

This measure covers the installation of a rigid, insulated cover installed on the inside of a room air conditioner (RAC) and a cover or sealing on the gap surrounding the unit. The cover is designed for permanently installed RAC units, which comprise window air conditioners and through-the-wall air conditioners, left in place throughout the heating season and reduces heating load by limiting the infiltration of cold outside air. To ensure persistence of savings, homeowner/building staff shall be instructed on proper annual removal and reinstallation. This measure assumes the cover is in place outside of the cooling season for the duration of the measure EUL.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Heating Equipment Only)

$$\Delta kWh = units \times \frac{1.08 \times CFM \times HDD \times 24}{Eff_{heating} \times 3{,}412}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Fuel Energy Savings (Fuel Heating Equipment Only)

$$\Delta MMBtu = units \times \frac{1.08 \times CFM \times HDD \times 24}{Eff_{heating} \times 1{,}000{,}000}$$

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
CFM	= Cubic foot per minute
HDD	= Heating degree day
$Eff_{heating}$	= Efficiency of heating system
1.08	= Specific heat of air × density of inlet air @ 70˚F × 60 min/hr[1]
24	= Hours in one day
3,412	= Conversion factor, one kWh equals 3,412 BTU
1,000,000	= Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

[1] The sensible heat constant at standard conditions of 1.08 is applied in accordance with standard HVAC industry practice. While the underlying assumptions are not representative characteristics of a NY heating season, the impacts to this value due to average heating season temperature and NY mean elevation offset such that the NY heating season specific value is approximately 1.08.

Variable	Value	Notes
CFM	19	Based on a negative pressure differential of 10 Pa. [2,3]
HDD		Look up in Heating Degree Days section below based on location.
$Eff_{heating}$		From application, based on existing equipment nameplate efficiency. If unknown, look up in table below based on equipment type and size. For electric resistance heat, use a value of 1.0.

Heating Degree Days

The table below presents the heating degree days (HDD) for several NY cities throughout the heating season (October 1st through May 31st).[4] Heating degree days represent the annual summation of the number of degrees that each day's average temperature is below some baseline temperature. The values below are distinct from HDD values used elsewhere in this TRM because they exclude degree days that fall on cooler evenings during the cooling season when the cover would not be in place. The baseline temperature reflects the temperature below which it is assumed a building needs to be heated. The HDD values below are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using a baseline temperature of 65° F.[5]

City	HDD
Albany	6,464
Binghamton	6,857
Buffalo	6,397
Massena	7,828
NYC	4,560
Poughkeepsie	6,099
Syracuse	6,425

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a room air conditioning unit in a multifamily building left in place through the heating season without a cover.

The baseline efficiency of the heating system is the nameplate efficiency of the existing equipment. If unknown, the baseline efficiency is that of a minimally code compliant system of type and capacity equivalent to the existing case.

If the existing equipment efficiency is unknown, the baseline efficiency for fossil fuel fired heating systems serving single-family homes and individual units is defined by the Code of Federal Regulations as shown in the table below.

[2] Steven Winter Associates, There Are Holes in Our Walls, April 2011, pg 13

[3] TRANE Engineers Newsletter, Managing the Ins and Outs of Commercial Building Pressurization, 2002, pg 6. A conservative estimation of building pressure differential throughout New York State during the heating season.

[4] NYC Department of Housing Preservation and Development, Residential Heat and Hot Water Requirements

[5] HDD during heating season calculated from NOAA National Centers for Environmental Information

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[6]

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	All Capacities	0.80 AFUE
Warm Air Furnace, Oil Fired	All Capacities	0.83 AFUE
Boiler, Hot Water, Gas Fired	All Capacities	0.82 AFUE
Boiler, Hot Water, Oil Fired	All Capacities	0.84 AFUE
Boiler, Steam, Gas Fired	All Capacities	0.80 AFUE
Boiler, Steam Oil Fired	All Capacities	0.82 AFUE

If the existing equipment efficiency is unknown, the baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[7] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Multiple Dwelling Units

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.80 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec
Boiler, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et

[6] 10 CFR 430.32(e)
[7] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5)

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a room air conditioning unit in a multifamily building with a cover and/or sealing on the surrounding gap through the heating season (October 1st through May 31st).[8] Building staff shall be instructed on proper annual removal and reinstallation to ensure persistence of savings.

Operating Hours

Assumed equipment operating hours are embedded in Heating Degree Day values.

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. There Are Holes in Our Walls; A Report Prepared for the Urban Green Building Council, by Steven Winter Associates, April 2011.
   Available from:
   https://urbangreencouncil.org/sites/default/files/there_are_holes_in_our_walls.pdf
2. TRANE Engineers Newsletter, Managing the ins and outs of Commercial Building Pressurization, Volume 31, No. 2, 2002
   Available from: https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/education-training/engineers-newsletters/airside-design/admapn003en_0502.pdf

[8] NYC Department of Housing Preservation and Development, Residential Heat and Hot Water Requirements

3. ECCCNYS 2020 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
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[ce]-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC403
4. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
5. NYC Department of Housing Preservation and Development, Residential Heat and Hot Water Requirements
   Available from: https://www1.nyc.gov/nyc-resources/service/1815/residential-heat-and-hot-water-requirements

Record of Revision

Record of Revision Number	Issue Date
6-14-1	6/19/2014
9-18-3	9/28/2018
3-19-3	3/29/2019
7-21-3	8/30/2021

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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 savings are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured to estimate energy savings.

This measure includes, but is not limited to, blown-in insulation in walls and ceilings. Cellulose is the most common blown-in insulation material; other materials include mineral fiber, loose-fill fiberglass, and Styrofoam pellets. Cellulose insulation is made from a cellular plant source, most commonly wood or paper, and treated with fire and pest resistant chemicals. Cellulose insulation is installed in three primary forms: loose-fill, stabilized and wall-cavity spray. Loose-fill insulation is a dry install that is blown into joist cavities in uninsulated attics or applied over existing batts. Stabilized cellulose is similar to loose-fill and applied in the same way but contains a moisture-activated adhesive that serves to increase the density of the cellulose and limit settling. Wall-cavity spray is typically applied prior to drywall installation in new construction, however insertion into existing walls is possible.

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.

For applications involving both wall and ceiling insulation, evaluate each component separately via the method below and sum together to determine total estimated energy savings.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

$$\Delta kWh_{cooling} = \frac{\left(\frac{1}{R_{baseline}} - \frac{1}{R_{baseline} + \Delta R}\right) \times A \times \left(1 - F_{framing}\right) \times CDD \times 24 \times F_{ElecCool}}{1{,}000 \times SEER}$$

$$\Delta kWh_{heating} = \frac{\left(\frac{1}{R_{baseline}} - \frac{1}{R_{baseline} + \Delta R}\right) \times A \times \left(1 - F_{framing}\right) \times HDD \times 24 \times F_{ElecHeat}}{1{,}000 \times HSPF}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\left(\frac{1}{R_{baseline}} - \frac{1}{R_{baseline} + \Delta R}\right) \times A \times \left(1 - F_{framing}\right) \times F_{ElecCool}}{1{,}000 \times EER} \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = \frac{\left(\frac{1}{R_{baseline}} - \frac{1}{R_{baseline} + \Delta R}\right) \times A \times \left(1 - F_{framing}\right) \times HDD \times 24 \times F_{FuelHeat}}{1{,}000{,}000 \times Eff_{FuelHeat}}$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fuel energy savings
$\Delta kWh_{cooling}$ = Annual electric cooling energy savings
$\Delta kWh_{heating}$ = Annual electric heating energy savings
$R_{baseline}$ = R-value of existing insulation (ft^2-F°-h/BTU)
ΔR = Difference in R-value between installed insulation and existing insulation (ft^2-F°-h/BTU)
A = Area of insulated surfaces (ft^2)
$F_{framing}$ = Framing factor
$F_{ElecCool}$ = Electric cooling factor; used to account for the presence or absence of an electric cooling system
CDD = Cooling Degree Days - The number of degrees that a day's average temperature is above some baseline temperature, which represents the temperature above which buildings need to be cooled. The baseline temperature is typically 65°F, but may vary based on application.
HDD = Heating Degree Days - The number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application.
$F_{ElecHeat}$ = Electric heating factor, used to account for the presence or absence of an electric heating system
$F_{FuelHeat}$ = Fuel heating factor, used to account for the presence or absence of a fuel heating system
SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, used for average U.S. location/region
HSPF = Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including supplemental heaters) during the heating season / total electric energy heat pump consumed (in watt-hour)
EER = Energy efficiency ratio under peak conditions (BTU/watt-hour)
$Eff_{FuelHeat}$ = Efficiency of fuel heating equipment (AFUE, Et, or Ec)
CF = Coincidence factor
24 = Hours in one day
1,000 = Conversion factor, one kW equals 1,000 watts
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$R_{baseline}$		From application. If unknown, lookup in Baseline Efficiency section below, based on building vintage and building envelope component. Assume default for uninsulated surfaces to be R-2 for ceilings and R-4 for walls, per the pre-war uninsulated brick vintage values in the table below.
ΔR		From application.
A		From application.
$F_{framing}$	Walls: 0.25 Ceilings: 0.07	ASHRAE.[9]
$F_{ElecCool}$		If an electric cooling system is present, set equal to 1. Otherwise, set equal to 0.
CDD		Lookup based on location in Heating and Cooling Degree Days table below.
HDD		Lookup based on location in Heating and Cooling Degree Days table below.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fuel heated. Otherwise, use 0.0.
SEER		From application. If unknown use 13 SEER, assuming a minimally code compliant, 3-ton, split system AC.[10]
HSPF		From application. If unknown use 8.2 HSPF, assuming a 3-ton central ASHP system.[11] For electric resistance heating and electric furnaces, use 3.4 HSPF. If taken from application, COP must be converted to HSPF using the equivalency HSPF = COP x 3.412.
EER		From application. If unknown, baseline EER is established as follows[12]: $EER = (1.12 \times SEER) - (0.02 \times SEER^2)$
$Eff_{FuelHeat}$		From application. If unknown, lookup based on system size and type in Baseline Efficiencies from which Energy Savings are Calculated section below.
CF	0.69	

Coincidence Factor (CF)

[9] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.
[10] ECCCNYS 2020, Table C403.3.2(1))
[11] Ibid.
[12] DOE, Building America House Simulation Protocols, October 2010

The prescribed value for the coincidence factor is 0.69.[13]

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). R-value of existing insulation shall come from application. If unknown, lookup in the Existing Building Envelope R-value table below based on building vintage and building envelope component. Alternatively, R-3.1 per inch of existing insulation may be applied.[14]

Existing Building Envelope R-value

Vintage	Wall	Ceiling
Pre-war uninsulated brick[15]	4	2
Prior to 1979[16]	7	11
From 1979 through 2006[17]	11	19
From 2007 through the present[18]	19	38 (Climate Zones 4 & 5) 49 (Climate Zone 6)

The baseline efficiency for fossil fuel fired heating systems serving single-family homes and individual units is the nameplate efficiency of the existing equipment. If unknown, the baseline efficiency is defined by the Code of Federal Regulations as shown in the table below.

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[19]

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	All Capacities	0.80 AFUE
Warm Air Furnace, Oil Fired	All Capacities	0.83 AFUE
Boiler, Hot Water, Gas Fired	All Capacities	0.82 AFUE
Boiler, Hot Water, Oil Fired	All Capacities	0.84 AFUE
Boiler, Steam, Gas Fired	All Capacities	0.80 AFUE
Boiler, Steam, Oil Fired	All Capacities	0.82 AFUE

[13] 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.

[14] DOE, Energy Saver, Insulation Materials. Assumes "low-density" fiberglass batts for 2 by 4 inch stud-framed wall (R-11/3.5 inch = R-3.1 per inch of insulation).

[15] Wall insulation assumes three 4'' brick layers; no insulation; 2'' air gap resistance only, Ceiling assumes no ceiling insulation, as captured in Appendix A of this TRM for Multi-Family Low-Rise

[16] Wall insulation assumes wood frame with siding; no insulation in 2 by 4 wall; 3.5 inch air gap resistance only, Ceiling assumes Minimal ceiling insulation, as captured in Appendix A of this TRM for Multi-Family Low-Rise

[17] Wall insulation assumes wood frame with siding; Fiberglass insulation in 2 by 4 wall per MEC 1980, Ceiling insulation assumes Fiberglass insulation per MEC 1980, as captured in Appendix A of this TRM for Multi-Family Low-Rise

[18] ECCCNYS 2007 as captured in Appendix A of this TRM for Multi-Family Low-Rise

[19] 10 CFR 430.32(e)

The baseline efficiency for heating systems serving multiple dwelling units is the nameplate efficiency of the existing system. If unknown, the baseline efficiency is defined by International Energy Conservation Code[20] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Multiple Dwelling Units

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.80 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec
Boiler, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

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. The installed R-value must be captured and included in the program application.

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 2020[21] 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

[20] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5)
[21] ECCCNYS 2020, Section R503 Building Thermal Envelope

compliance.

Operating Hours

Effective heating and cooling hours associated with benefits of opaque shell insulation are established via the Heating and Cooling Degree Days section below.

Heating and Cooling Degree Days[22]

City	HDD	CDD
Albany	6,680	597
Binghamton	7,193	382
Buffalo	6,617	544
Massena	8,196	363
NYC	4,671	1,160
Poughkeepsie	6,210	671
Syracuse	6,651	570

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. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. ECCCNYS 2020 Section R402 Building Thermal Envelope
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[ce]-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC402
3. ECCCNYS 2020 Section R403 Systems
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[re]-residential-energy-efficiency#NYSECC2020P1_RE_Ch04_SecR403
4. ECCCNYS 2020 Section R503 Alterations
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-5-re-existing-buildings
5. Building America House Simulation Protocols, Robert Henderon and Cheryn Engebrecht, National Renewable Energy Laboratory, October 2010
   Available from: https://www.nrel.gov/docs/fy11osti/49246.pdf

[22] HDD/CDD taken from NCEI 1981-2010 climate normal using a 65 °F balance point.

6. 10 CFR 430.32 Energy and water conservation standards and their compliance dates
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=dfe00d44cfd9ab9ead4019d69702652a&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132
7. ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.
8. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
9. DOE, Energy Saver, Insulation Materials
Available from: https://www.energy.gov/energysaver/weatherize/insulation/insulation-materials#fiberglass

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
12-20-2	12/31/2020
3-21-5	4/9/2021
7-21-5	8/30/2021

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DOMESTIC HOT WATER

HEAT PUMP WATER HEATER (HPWH) – AIR SOURCE

Measure Description

This measure covers the installation of electric storage tank water heaters that use heat pump technology to move heat from the air (in conditioned or unconditioned spaces) to the water storage tank and are designed to heat and store potable water at a thermostatically controlled temperature of less than 180°F. It is not intended for equipment delivering process or space heating hot water. It applies to electric heat pump water heaters with a maximum current rating of 24 amperes at a voltage no greater than 250 volts and with a rated storage tank capacity of 120 gallons or less.[23,24]

This measure applies to new construction/major renovation projects and replacement of existing water heaters. Baseline equipment in new construction/major renovation shall be a minimally code compliant, gas-fired storage type water heater where gas service is available and a minimally code compliant, electric storage type water heater elsewhere. Baseline efficiency for replacement of equipment shall be a minimally code compliant system of the same type as the existing equipment.

This measure applies to residential applications as well as residential-duty water heaters installed in commercial settings. In the latter case, this methodology shall be employed utilizing typical GPD values as defined in the "Gallons per Day (GPD)" section of the Commercial Storage Tank Water Heater measure detailed in this document.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{F_{eDHW}}{UEF_{baseline}} - \frac{1}{UEF_{ee} \times F_{derate}}\right) + \Delta kWh_{cooling} - \Delta kWh_{heating}$$

$$\Delta kWh_{cooling} = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \frac{1}{UEF_{ee}} \times F_{Loc} \times \frac{F_{Cool}}{SEER/3.412}$$

$$\Delta kWh_{heating} = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \frac{1}{UEF_{ee}} \times F_{Loc} \times F_{ElecHeat} \times \frac{F_{Heat}}{HSPF/3.412}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times (\Delta kW/unit)$$

Annual Fuel Energy Savings

[23] ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2, September 2017

[24] 10 CFR 430.2

$$\Delta MMBtu = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{1{,}000{,}000} \times \left[\frac{F_{FFDHW}}{UEF_{baseline}} + \frac{F_{BoilerDHW}}{AFUE} - \left(\frac{1}{UEF_{ee}} \times F_{loc} \times F_{FuelHeat} \times \frac{F_{Heat}}{AFUE}\right)\right]$$

where:

ΔkWh = Annual electric energy savings

ΔkW = Peak coincident demand electric savings

ΔMMBtu = Annual fuel energy savings

$\Delta kWh_{cooling}$ = Annual electric cooling energy savings as a result of interactivity with the building's HVAC system (electric cooling bonus)

$\Delta kWh_{heating}$ = Annual electric heating energy savings as a result of interactivity with the building's HVAC system (electric heating penalty)

units = Number of measures installed under the program

GPD = Gallons per day

ΔT_{main} = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)

F_{eDHW} = Electric water heating factor, used to exclude baseline electric water heating consumption if no baseline electric water heating is present

F_{FFDHW} = Fossil fuel water heating factor, used to exclude baseline fossil fuel water heating consumption if no baseline fossil fuel fired direct water heating is present

$F_{BoilerDHW}$ = Fossil fuel water heating factor, used to exclude baseline fossil fuel water heating consumption if no baseline fossil fuel fired boiler-driven indirect water heating is present

baseline = Characteristic of baseline condition

ee = Characteristic of energy efficient condition

UEF = Uniform energy factor

F_{derate} = Efficiency derating factor used to account for the degradation of heat pump performance present in systems installed in unconditioned spaces

F_{Loc} = Installation location factor, used to exclude interactive HVAC impacts for systems installed in unconditioned spaces

F_{Cool} = Cooling factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that reduces space cooling load

F_{Heat} = Heating factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that increases space heating load

$F_{ElecHeat}$ = Electric heating factor, used to exclude electric heating penalty if no electric heating is present

$F_{FuelHeat}$ = Fossil fuel heating factor, used to exclude fossil fuel heating penalty if no fossil fuel heating is present

SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watthour, (used for average U.S. location/region)

HSPF = Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt-hour)

AFUE = Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment

(ΔkW/unit) = Deemed peak coincident demand savings per measure

365 = Days in one year
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kWh equals 3,412 BTU
3.412 = Conversion factor, one watt-hour equals 3.412 BTU
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[25]
ΔT_{main}	T_{set} - T_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F).
T_{set}	125	Water heater set point temperature (°F).[26]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
F_{eDHW}		Use a value of 1.0 if the water was previously heated with electricity or if it is a new construction home with no gas access. Otherwise, use 0.0.
F_{FFDHW}		Use a value of 1.0 if the water was previously heated directly with fossil fuels or if it is a new construction home with gas access. Otherwise, use 0.0.
$F_{BoilerDHW}$		Use a value of 1.0 if the water was previously heated indirectly with fossil fuels through the boiler system. Otherwise, use 0.0.
$UEF_{baseline}$		Uniform Energy Factor of the baseline condition. See Baseline Efficiencies… section below for details regarding derivation of this input.
UEF_{ee}		Uniform Energy Factor of the energy efficient measure, from application.
F_{derate}		For equipment installed in unconditioned spaces, lookup in Derate Factor table below based on installation location and nearest city. For equipment installed in conditioned spaces, a value of 1.0 shall be used.
F_{Loc}		Use a value of 1.0 if the water heater is installed in a conditioned space. Otherwise, use 0.0.
F_{Cool}		Lookup in HVAC Interactivity table below based on nearest city.
F_{Heat}		Lookup in HVAC Interactivity table below based on nearest city.

[25] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
[26] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.

Variable	Value	Notes
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise, use 0.0.
SEER	13	Assumed efficiency of existing air conditioning system, based on a minimally code compliant, 3-ton, split system AC.[27]
HSPF	Heat Pump: 8.2 Electric Resistance: 3.412	Assumed efficiency of electric heating system, based on a COP of 1.0 for electric resistance heating and a minimally code compliant, 3-ton split system HP for heat pumps.[28]
AFUE		From application. If unknown, lookup from Baseline Efficiencies section based on existing equipment type. For new construction/gut rehab or if equipment type is unknown, assume an 80 MBH gas furnace.
(ΔkW/unit)		Deemed Summer Peak Coincident Demand Savings. Use a value of 0.17 if the water was previously heated with electricity in replacement scenarios and if there is no gas service available in new construction/gut rehab scenarios.[29] Otherwise, use -0.17 for an electric penalty.[30]

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[31] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[32] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

[27] ECCCNYS 2020, Table C403.3.2(1)
[28] ECCCNYS 2020, Table C403.3.2(2)
[29] "Field Testing of Pre-Production Prototype Heat Pump Water Heaters" Federal Energy Management Program, DOE/EE-0317, May 2007.
[30] "CT HVAC and Water Heater Process and Impact Evaluation and CT Heat Pump Water Heater Impact Evaluation", West Hill Energy and Computing, Final Report R1614/R1613, July 19, 2018
[31] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[32] Average annual outdoor temperatures taken from NCDC 1981-2010 climate normals

Derate Factor

Standard testing conditions for rating of heat pump water heaters require a dry bulb temperature of 67.5°F ± 1°F and a relative humidity of 50% ±2%.[33] The reported efficiency of heat pump water heaters is established at these conditions; however, heat pump efficiency degrades at lower ambient temperatures. The Derate Factor is established to adjust the published efficiency of the qualifying heat pump water heater when the system is installed in semi-conditioned or unconditioned spaces, namely, garages and basements. The values shown below were derived from Table 10 of Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates published by Bonneville Power Administration in 2011[34] and verified via comparison with results from the 2013 NEEA Heat Pump Water Heater Field Study Report.[35] Average values from northwest heating zones 1 (<6,000 HDD), 2 (6,000 – 7,500 HDD) and 3 (>7,500 HDD)[36] from this analysis and comparison were then mapped to representative NY climate regions as shown below.

City	F_{derate} (Unconditioned Basement Installation)	F_{derate} (Garage Installation)
Albany	0.80	0.78
Binghamton	0.80	0.78
Buffalo	0.80	0.78
Massena	0.75	0.69
NYC	0.86	0.83
Poughkeepsie	0.80	0.78
Syracuse	0.80	0.78

HVAC Interactivity

Because heat pump water heaters operate via the transfer of heat from the ambient air to the water in the storage tank, systems installed in conditioned spaces will interact with the building's HVAC system. The values shown in the table below reflect the percentage of heat extracted from the ambient air by the heat pump that either decreases the building's cooling load (F_{Cool}) or increases the building's heating load (F_{Heat}). These values were derived from Table 12 of Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates published by Bonneville Power Administration in 2011[37] and key operating assumptions specified therein. Average values from northwest heating zones 1 (<6,000 HDD), 2 (6,000 – 7,500 HDD) and 3 (>7,500 HDD)[38] were then mapped to representative NY climate regions and scaled linearly based on regional HDD and CDD. The HDD and CDD values are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using base 65° F.[39]

City	CDD	F_{Cool}	HDD	F_{Heat}

[33] 10 CFR 430 Subpart B Appendix E
[34] Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates, Bonneville Power Administration, November 2011
[35] NEEA Heat Pump Water Heater Field Study Report, Fluid Market Strategies, October 2013
[36] NW Council Heating/Cooling zone maps
[37] Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates, Bonneville Power Administration, November 2011
[38] NW Council Heating/Cooling zone maps
[39] HDD/CDD taken from NCEI 1981-2010 climate normals

Albany	597	0.26	6,680	0.70
Binghamton	382	0.17	7,193	0.76
Buffalo	544	0.24	6,617	0.70
Massena	363	0.16	8,196	0.84
Poughkeepsie	671	0.29	6,210	0.65
NYC	1,160	0.51	4,671	0.49
Syracuse	570	0.25	6,651	0.70

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A. Deemed demand savings values incorporate system peak coincidence considerations.

Baseline Efficiencies from which Savings are Calculated

The baseline for a non-fuel switching normal replacement at end of the appliance effective useful life (EUL), in new construction, or substantial renovation scenarios is the minimally-compliant state or municipal energy code or federal standard, that is applicable to the measure or system being installed.

The baseline for a fuel switching installation at the end of the appliance effective useful life is the minimally-compliant, state or municipal energy code or federal standard, that is applicable to the measure or system, similar to the existing measure or system, that the consumer would have had installed without the influence of the energy efficiency program.

The baseline for a system being installed prior to the end of useful life of the existing on-site equipment may be considered as an Early Replacement; consistent with methods described in Appendix M, *Guidelines for Early Replacement* of this TRM. The non-fuel switching and fuel switching baselines detailed above shall be considered where applicable when calculating Remaining Useful Life (RUL).

$UEF_{baseline}$ shall be calculated as a function of qualifying equipment tank volume (v_t) per federal standards[40] as shown in the table below, using the qualifying equipment capacity and draw pattern. Draw pattern can be established based on the proposed equipment First Hour Rating (FHR), rated in gallons. See First Hour Rating vs. Draw Pattern table below. If FHR is unknown, a Medium draw pattern should be assumed for equipment with rated storage capacity ≤50 gallons and a High draw pattern should be assumed otherwise.[41]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x v_t)
		Low	0.9254 - (0.0003 x v_t)
		Medium	0.9307 - (0.0002 x v_t)
		High	0.9349 - (0.0001 x v_t)

[40] 10 CFR 430.32(d)

[41] Based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
	> 55 gal and ≤ 120 gal	Very Small	1.9236 - (0.0011 x v_t)
		Low	2.0440 - (0.0011 x v_t)
		Medium	2.1171 - (0.0011 x v_t)
		High	2.2418 - (0.0011 x v_t)
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.3456 – (0.0020 x v_t)
		Low	0.5982 – (0.0019 x v_t)
		Medium	0.6483 – (0.0017 x v_t)
		High	0.6920 – (0.0013 x v_t)
	> 55 gal and ≤ 100 gal	Very Small	0.6470 – (0.0006 x v_t)
		Low	0.7689 – (0.0005 x v_t)
		Medium	0.7897 – (0.0004 x v_t)
		High	0.8072 – (0.0003 x v_t)
Oil-Fired Storage Water Heater	≤ 50 gal	Very Small	0.2509 – (0.0012 x v_t)
		Low	0.5330 – (0.0016 x v_t)
		Medium	0.6078 – (0.0016 x v_t)
		High	0.6815 – (0.0014 x v_t)

*v_t = tank volume in gallons

First Hour Rating vs. Draw Pattern[42]

First Hour Rating	Draw Pattern
<18 gallons	Very Small
≥18 and <51 gallons	Low
≥51 and <75 gallons	Medium
≥75 gallons	High

The baseline efficiency for fossil fuel fired heating systems serving single-family homes and individual units is defined by the Code of Federal Regulations as shown in the table below.

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[43]

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	All Capacities	0.80 AFUE
Warm Air Furnace, Oil Fired	All Capacities	0.83 AFUE
Boiler, Hot Water, Gas Fired	All Capacities	0.82 AFUE
Boiler, Hot Water, Oil Fired	All Capacities	0.84 AFUE
Boiler, Steam, Gas Fired	All Capacities	0.80 AFUE
Boiler, Steam, Oil Fired	All Capacities	0.82 AFUE

[42] 10 CFR 429.17
[43] 10 CFR 430.32(e)

The baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[44] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Multiple Dwelling Units

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.80 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec
Boiler, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a heat pump water heater meeting minimum performance requirements specified in ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2.[45] Per that specification, heat pump water heaters with ≤55 gallon storage capacity must have a UEF ≥ 2.00 and heat pump water heaters with >55 gallon storage capacity must have UEF ≥2.20.

Operating Hours

Water heater run hours are not utilized in the estimation of energy or demand savings, but water

[44] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5)
[45] ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2, September 2017

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Heat pump water heaters installed in conditioned spaces will result in an increase in space heating load due to the extraction of heat from the ambient air. This interactivity is addressed in the prescribed methodology.

Ancillary Electric Savings Impacts

Heat pump water heaters installed in conditioned spaces will result in an increase in space heating load and a decrease in cooling load due to the extraction of heat from the ambient air. This interactivity is addressed in the prescribed methodology.

References

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Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-13-3	6/30/2013
11-13-2	11/26/2013

12-17-7	12/31/2017
12-18-3	12/31/2018
2-20-1	2/28/2020
7-21-7	8/30/2021

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LIGHTING

INTERIOR AND EXTERIOR LIGHTING

Measure Description

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

Beginning January 2012 and phased in through January 2014, the Energy Independence and Security Act of 2007 (EISA) regulations stipulated typical screw-based general service lamps with wattages ranging from 40W to 100W to comply with new lamp wattage standards such that the range of wattages decreased to be from 29W to 72W for rated lumen output ranging from 310 to 2,600 lumens.[46] Deemed baseline values for this measure will apply wattages based on lamp type and light output (lumens).[47]

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 Fuel Energy Savings

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

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	= Rated wattage of lamp and/or fixture (Watts)
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition
hrs	= Lighting operating hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour

[46] The maximum rated wattage varies for modified spectrum lamps.
[47] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 86

$HVAC_{ff}$ = 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
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 depending on program structure/delivery mechanism.
hrs		Look up in Operating Hours section below based on installation type and location. "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.
$HVAC_{ff}$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual fuel energy consumption (MMBtu/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	Interior: 0.16 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 0.16.[48] This value shall also be used if the installation location is unknown.

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. [49]

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), some 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 below. 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.[50]

Lumen Range **(a)**	**EISA 2007 Incandescent Equivalent** **$W_{baseline}$** **(b)**	**EISA-Exempt Incandescent Equivalent** **$W_{baseline}$** **(c)**
310 – 749	29	40
750 – 1,049	43	60
1,050 – 1,489	53	75
1,490 – 2,600	72	100

Specialty Lamps

[48] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table 4-4: Peak Period Coincidence Factors and Confidence Intervals – Efficient Bulbs. CF referenced reflects Average Summer for NYSERDA based on ISO-NE peak period. The NYSERDA model includes UNY and DNY. The NYSERDA model does not differentiate between interior and exterior lighting. The interior lighting sample size is significantly larger than the exterior sample size. Thus, reported Coincidence Factor is appropriate for interior lighting and unknown installations.

[49] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 89

[50] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 82-86

Baseline wattage for specialty lamps are found in the table below. Specialty lamps are defined as screw-base lamps that are globe, bullet, candle or decorative shaped. These can be medium base, intermediate base, or candelabra base lamps. EISA 2007 set specific limits on maximum rated wattage for incandescent intermediate and candelabra base lamps, 40W and 60W respectively. In addition, some medium screw-base specialty lamps that could be used for general service applications are specifically exempt from EISA 2007 wattage limits and include: 1) a G shape lamp with a diameter of 5 inches or more (i.e. a G40 lamp); 2) a T shape lamp that uses not more than 40 watts or has a length of more than 10 inches; (3) a B, BA, CA, F, G16–1/2, G–25, G30, S, or M–14 lamp of 40 watts or less; and 4) a silver bowl lamp.[51] Medium screw-base specialty lamps not exempt from EISA 2007 must meet the maximum wattage requirements outlined in EISA 2007. For these lamps, the baseline wattage from column (b) in the table above should be used based on the lumen output. For specialty lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage should be used.

Bulb Type (a)	**Base Type (b)**	**Lumen Range (c)**	**$W_{baseline}$[52] (d)**
Globe	Medium and intermediate base	90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 749	40
	Candelabra base	90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 499	40
		500 – 1,049	60
Decorative (Shapes B, BA, C, CA, DC, F, G)	Medium and intermediate base	70 – 89	10
		90 – 149	15
		150 – 299	25
		300 – 749	40
	Candelabra base	70 – 89	10
		90 – 149	15
		150 – 299	25
		300 – 449	40
		450 – 1,049	60

Reflector/Flood Lamps

Baseline wattage for reflector and flood type lamps are found in the tables below. For reflector and flood lamps that are not covered by the table below, either based on bulb type or lumen output, the manufacturer recommended baseline wattage should be used. The first part of the table lists the baseline wattage for the incandescent reflector lamp bulb types specifically exempted from federal standards and include 1) Lamps rated at 50 watts or less that are ER30,

[51] Ibid

[52] The baseline wattage for the specialty lamps is calculated by dividing the midpoint lumen output for the range by the mean efficacy for "General Purpose- Incandescent Omni" for Globe bulbs and "Decorative- Incandescent Omni" for Decorative bulbs found in Table C.2 (page 82) from the Energy Savings Forecast of Solid-State Lighting in General Illumination Applications Report (US DOE, 2019). The calculated baseline wattage is rounded to a standard wattage output or the maximum rated wattage for that category.

BR30, BR40, or ER40 lamps; 2) Lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; or 3) R20 incandescent reflector lamps rated 45 watts or less. [53]

Exempt Bulb Type (a)	Lumen Range (b)	$W_{baseline}$[54] (c)
ER30, BR30, BR40, or ER40	300 – 399	40
	400 – 649	50
BR30, BR40, or ER40	650 – 1,183	65
R20	< 300	30
	300 – 450	45

Not Exempt Bulb Type (a)	Diameter (b)	Lumen Range (c)	$W_{baseline}$[55] (d)
All other R, PAR, ER, BR, BPAR, or similar bulb shapes, with diameter >2.25", other than those listed above	> 2.25" and ≤ 2.5"	400 – 718	40
		719 – 810	50
		811 - 1,002	55
		1,003 – 1,202	65
		1,203 – 1,516	75
		1,517 – 1,733	90
		1,734 – 2,184	100
		> 2,184	120
	> 2.5"	639 – 847	40
		848 – 956	50
		957 – 1,183	55
		1,184 – 1,419	65
		1,420 – 1,789	75
		1,790 – 2,045	90
		2,046 – 2,578	100
		> 2,578	120

Other Bulb Types (a)	Diameter (b)	Lumen Range (c)	$W_{baseline}$[56] (d)
	≤ 2.25"	300 – 399	40

[53] Electronic Code of Federal Regulations, Title 10: Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, Subpart C—Energy and Water Conservation Standards

[54] The baseline wattage for the exempt reflector/flood lamps is calculated by dividing the midpoint lumen output for the range by the mean efficacy for "Downlights- Incandescent Directional" bulbs found in Table C.2 (page 82) from the Energy Savings Forecast of Solid-State Lighting in General Illumination Applications Report (US DOE, 2019). The calculated baseline wattage is rounded to a standard wattage output or the maximum rated wattage for that category.

[55] The baseline wattage is calculated based on the standards outlined in the Electronic Code of Federal Regulations, Title 10: Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, Subpart C—Energy and Water Conservation Standards

[56] The baseline wattage for the other reflector/flood bulb types is calculated by dividing the midpoint lumen output for the range by the mean efficacy for "Small Directional (MR16)- Halogen" for the MR16 bulbs or by "Downlights- Incandescent Directional" for all other bulbs found in Table C.2 (page 82) from the Energy Savings

Other Bulb Types (a)	Diameter (b)	Lumen Range (c)	$W_{baseline}$[56] (d)
All ER, BR, BPAR, or similar bulb shapes		400 – 499	50
		500 – 599	60
		600 – 1,000	65
MR16	2”	< 450	35
		450 – 600	50
		> 600	75
All other reflector lamps not included above	All	200 – 299	30
		300 – 399	40

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

Look up operating hours from the table below, based on lamp location and city. See details below for derivation of operating hours. “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.

City	Interior	Exterior	Unknown
Albany	986	2,081	1,022
Binghamton	986	2,081	1,022
Buffalo	986	2,081	1,022
Massena	986	2,081	1,022
NYC	1,752	2,117	1,752
Poughkeepsie	986	2,081	1,022
Syracuse	986	2,081	1,022

<u>NYS cities other than NYC, Interior</u>

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 New

Forecast of Solid-State Lighting in General Illumination Applications Report (US DOE, 2019). The calculated baseline wattage is rounded to a standard wattage output or the maximum rated wattage for that category.

York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[57]

NYS cities other than NYC, Exterior

Hours of operation for exterior lighting is estimated to be 5.7 operating hours per day or 2,081 (5.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island. [58]

NYS cities other than NYC, Unknown

Hours of operation for lighting installed in an unknown location is estimated to be 2.8 operating hours per day or 1,022 (2.8 x 365) hours per year. This value is a weighted average of interior and exterior lighting hours derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[59]

NYC, Interior

Hours of operation for exterior lighting is estimated to be 4.8 operating hours per day or 1,752 (4.8 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York City and Westchester County.[60]

NYC, Exterior

Hours of operation for exterior lighting is estimated to be 4.4 operating hours per day or 1,606 (4.4 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York City and Westchester County.[61]

NYC, Unknown

Hours of operation for lighting installed in an unknown location is estimated to be 4.8 operating hours per day or 1,752 (4.8 x 365) hours per year. This value is a weighted average of interior and exterior lighting hours derived from on-site lighting inventories of homes in New York City and Westchester County.[62]

[57] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-5: HOU by Area Adjusted for Snapback, Table 3-2: Sample Sizes, Overall HOU Estimates by Area and Room, and hierarchical model as described in section 2.6.3 (p. 22). HOU referenced is a weighted average of interior room types for UNY and is Snapback Adjusted.

[58] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-5: HOU by Area Adjusted for Snapback and hierarchical model as described in section 2.6.3 (p. 22). HOU referenced is the value for Exterior for UNY and is Snapback Adjusted.

[59] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-5: HOU by Area Adjusted for Snapback and hierarchical model as described in section 2.6.3 (p. 22). HOU referenced is the value for Household for UNY, which is a weighted average of all room types and is Snapback Adjusted.

[60] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-6: HOU by Area Adjusted for Snapback and Table 3-2: Sample Sizes, Overall HOU Estimates by Area and Room. HOU referenced is a weighted average for interior room types for DNY and is Snapback Adjusted.

[61] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-6: HOU by Area Adjusted for Snapback. HOU referenced is the value for Exterior for DNY and is Snapback Adjusted.

[62] NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014. Table ES-6: HOU by Area Adjusted for Snapback. HOU referenced is the value for Household for DNY, which is a weighted average of all room types and is Snapback Adjusted. The study's sample size included far more interior to exterior lights, thus a weighted distribution heavily favors the interior lighting hours.

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.

References

1. Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 82-86
   Available from: https://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf
2. NMR Group Inc., "Northeast Residential Lighting Hours-of-Use Study", May 5, 2014.
   Available from: https://neep.org/sites/default/files/resources/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf
3. Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007.
   Available from:
   https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/116_RLW_CF%20Res%20C&I%20ltg.pdf
4. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, US Department of Energy, December 2019, p. 82.
   Available from: https://www.energy.gov/sites/prod/files/2020/02/f72/2019_ssl-energy-savings-forecast.pdf
5. Electronic Code of Federal Regulations, Title 10: Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, Subpart C—Energy and Water Conservation Standards
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=1ae0322478999c2c4ff2c83d9ce4c04a&rgn=div8&view=text&node=10:3.0.1.4.18.3.9.2&idno=10l

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-2	7/31/2013
6-15-3	6/1/2015
1-16-3	12/31/2015
1-17-4	12/31/2016

9-17-2	9/30/2017
12-19-6	12/23/2019
12-19-7	12/23/2019
12-20-13	12/31/2020
7-21-9	8/30/2021

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OTHER

SOLAR POOL HEATER

Measure Description

This measure covers the installation of solar pool heating systems utilizing glazed or unglazed solar thermal collectors. Solar thermal collectors absorb sunlight, convert solar energy directly into heat and transfer heat to filtered pool water pumped through the system. Thermal collectors shall be permanently installed on a roof or raised frame.

Solar pool heaters may be installed to partially or fully offset energy consumption of traditional heaters. This measure only applies to solar pool heaters installed in place of or to supplement fossil fuel pool heaters for inground swimming pools. Installed thermal collector area must be 50-100% of pool surface area.[63] This methodology assumes that thermal collectors experience minimal shading between the hours of 10AM and 4PM during the summer months. Qualifying thermal collectors must be rated by Solar Rating & Certification Corporation (SRCC) and be OG-100 certified.[64]

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

For Single Speed Pool Pumps

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

For Multi-Speed or Variable Frequency Drive Pool Pumps

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

Summer Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Fuel Energy Savings

$$\Delta MMBtu = \frac{CR \times SF \times days \times (1 - F_{derate})}{E_{t,baseline} \times 1{,}000{,}000}$$

where:

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

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

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
$\Delta MMBtu$ = Annual fuel energy savings
$_{baseline}$ = Characteristic of baseline condition
$_{ee}$ = Characteristic of energy efficient condition
$_{HS}$ = High speed operation
$_{LS}$ = Low speed operation
CR = Collector Rating (Btu/ft^2-day)
SF = Square Footage of thermal collectors (ft^2)
days = Annual days pool heater is used
F_{derate} = Derating factor
F = Weighting factor
$hrs_{baseline}$ = Annual pool pump operating hours with fossil fuel-fired pool heater
hrs_{ee} = Annual pool pump operating hours with solar pool heater
EF = Energy factor (kgal/kWh)
WEF = Weighted Energy factor (kgal/kWh)
GPM = Gallons per minute
$E_{t,baseline}$ = Thermal efficiency of baseline pool heater
60 = Conversion factor, minutes per hour
1,000 = Conversion factor, one kW equals 1,000 watts
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
CR		From application, as rated by Solar Rating & Certification Corporation. Value shall reflect scenario A (Pool Heating – Warm Climate) and Medium Radiation (1,500 Btu/ft^2-day).[65]
SF		From application.
days		From application. If unknown, use 122 as default, based on 4 months of operation per year.
F_{HS}	0.2	Code of Federal Regulations. [66]
F_{LS}	0.8	Code of Federal Regulations. [67]
F_{derate}	0.06	Derating factor considers approximate shading (3% deration) and operational availability (3% deration).[68]
$hrs_{baseline}$		From application. If unknown, use 9.4[69] as default for a single-speed pump, based on a 1.5 HP pump, 22,000 gallon pool, and assuming two turnovers per day for baseline condition.[70]
hrs_{ee}		From application.

[65] Solar Rating & Certification Corporation Directory; scenario selected based on review of NASA Open Data Portal, Prediction of Worldwide Energy Resources (POWER), suggesting that this is the most appropriate selection across NY cities.
[66] 10 CFR Appendix B to Subpart Y of Part 431 – Uniform Test Method for the Measurement of Energy Efficiency of Dedicated-Purpose Pool Pumps
[67] Ibid
[68] NREL "PVWatts Version 5 Manual" Table 6.
[69] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 7/14/2020)
[70] CEE^{SM} High Efficiency Residential Swimming Pool Initiative, January 2013, pg 33

Variable	Value	Notes
GPM		Look up in Baseline Efficiencies section below, based on pool pump type (single speed, multi-speed, or variable frequency drive) and nameplate hp.
EF		Look up in Baseline Efficiencies section below, based on nameplate hp.
WEF		Look up in Baseline Efficiencies section below, based on nameplate hp.
$E_{t,baseline}$		From application. If unknown, apply 0.86 as default in partial displacement of pool heater load scenarios and 0.82 as default in complete replacement of pool heater load scenarios. [71]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is a standard efficiency fossil fuel-fired pool heater. The values for baseline EF, WEF and GPM are found in the table below, based on pump type and nameplate horsepower. Pump Performance Curve C is assumed for all 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.

Single Speed Pool Pumps[72]

Pump Type and Variable	Nameplate Horsepower					
	3	2.5	2	1.5	1	0.75
EF	2.0	2.2	2.3	2.3	2.5	3.3
GPM	102	93	89	78	76	65

Multi-Speed and Variable Frequency Drive Pool Pumps[73]

Pump Type and Variable	Nameplate Horsepower at High Speed				
	1.65 hhp (3 HP)	1.25 hhp (2.5 HP)	1.18 hhp (2 HP)	0.95 hhp (1.65 HP)	0.72 hhp (1-1.4 HP)
WEF	3.6	4.0	4.1	4.6	4.9
GPM_{HS}	102.0	90.0	89.7	78.0	70.0
GPM_{LS}	51.0	45.7	44.8	41.8	40.3

Compliance Efficiency from which Incentives are Calculated

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

[71] 10 CFR 430.32 (k)(2)
[72] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 7/14/2020)
[73] Ibid

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

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

References

1. Department of Energy, Solar Swimming Pool Heaters
   Available from: https://www.energy.gov/energysaver/solar-swimming-pool-heaters
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   Available from: https://data.nasa.gov/Earth-Science/Prediction-Of-Worldwide-Energy-Resources-POWER-/wn3p-qsan
6. Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps, April 2020
   Available from: https://www.energystar.gov/productfinder/product/certified-pool-pumps/results#
7. CEE℠ High Efficiency Residential Swimming Pool Initiative, Consortium for Energy Efficiency, January 2013
   Available from:
   https://library.cee1.org/system/files/library/9986/CEE_Res_SwimmingPoolInitiative_01Jan2013_Corrected.pdf
8. 10 CFR 430.32 Energy and water conservation standards and their compliance dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=840d2f09fea283237b0f345001c03a28&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132
9. 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

Record of Revision

Record of Revision Number	Issue Date
3-20-1	3/30/2020
7-21-11	8/30/2021

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AGRICULTURAL EQUIPMENT

HIGH SPEED FAN

Measure Description

This measure is applicable to the installation of high speed, high efficiency fans installed in agricultural applications. For the purposes of this measure, a high speed fan shall consist of the blade and motor assembly. Ventilation, exhaust and circulating high speed fans improve animal comfort, control moisture and maintain indoor air quality for livestock and other agricultural applications. Variable frequency drives (VFD) may be installed along with high speed fans to increase energy savings and the associated savings are quantified by this methodology. If VFD savings are claimed via this measure, additional savings may not be claimed for VFDs utilizing a separate methodology. Qualifying fans must be rated by an Air Movement and Control Association (AMCA) accredited laboratory such as Bioenvironmental and Structural Systems (BESS) Laboratories.[74] An alternative energy savings approach is provided for circulating fans when manufacturer ratings are in lbf/kW.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

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

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

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

Alternative Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings for Circulating Fans when Manufacturer Ratings are in lbf/kW

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

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

Summary of Variables and Data Sources

Variable	Value	Notes
$CFM_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use CFM_{ee} as the default value.
CFM_{ee}		From application.
$(CFM/watt)_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If not tested by BESS Labs, look up from Baseline Efficiencies section below based on fan diameter.
$(CFM/watt)_{ee}$		From application, look up from BESS Labs database based on manufacturer and model number or as rated by other third-party accredited laboratory
$lbf_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use lbf_{ee} as the default value.
lbf_{ee}		From application.
$(lbf/kW)_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If not tested by BESS Labs, look up from Baseline Efficiencies section below based on fan diameter.
$(lbf/kW)_{ee}$		From application, look up from BESS Labs database based on manufacturer and model number or as rated by other third-party accredited laboratory
$F_{VFD,ee}$	No VFD: 1.00 VFD (Greenhouse): 0.64 VFD (Poultry/Livestock): 0.75	Adjustment to efficient condition consumption to account for VFD control, based on presence of VFDs and fan application.[75]
hrs		From application. If unavailable, lookup in Operating Hours section below.
CF	1.0	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 1.0.[76]

Baseline Efficiencies from which Energy Savings are Calculated

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

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

The baseline condition for this measure is a standard efficiency exhaust, ventilation or circulating fan. Baseline fan airflow (CFM) for exhaust and ventilation fans or thrust (lbf) for circulating fans and fan efficiency shall come from application. If unavailable, look up from the table below based on fan type and diameter.[77]

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is a high speed exhaust, ventilation or circulating fan that meets or exceeds the minimum efficiency requirements from the table below, based on fan type and diameter.[78]

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

Operating Hours

Fan operating hours shall come from application. If operating hours are unknown, the prescribed hours shall come from the lookup table below based on location. Default hours are developed from NOAA hourly normals by summing annual hours dry bulb temperature is above 50ºF.[79]

City	Circulating Fan Hours	Exhaust/Ventilation Fan Hours[80]
Albany	4,238	6,570
Binghamton	3,969	6,570
Buffalo	4,189	6,570
Massena*	4,156	6,570
NYC	5,162	6,570
Poughkeepsie**	4,722	6,570

[77] Default baseline efficiency was determined by calculating the 10th percentile of the efficiencies of all fans in the active BESS Labs database for the respective fan diameter ranges. Many low efficiency fans are often not tested by BESS Labs, therefore the average tested fan is more efficient than the average market available fan. Ventilation and exhaust fan CFM and circulating fan lbf represent the averages of each diameter range, regardless of fan efficiency. The database includes single and three phase fans at four voltages.

[78] Minimum qualifying fan efficiency is equivalent to the 75th percentile of all BESS Labs tested in the respective fan diameters. The database includes single and three phase fans at four voltages.

[79] NOAA National Centers for Environmental information – NCEI 2010 Hourly Normals

[80] Exhaust/Ventilation fans are assumed to operate 75% of total annual hours (8,760 x 0.75 = 6,570).

City	Circulating Fan Hours	Exhaust/Ventilation Fan Hours[80]
Syracuse	4,179	6,570

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Record of Revision Number	Issue Date
3-20-3	3/30/2020
7-21-12	8/30/2021

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

HIGH-VOLUME LOW SPEED (HVLS) FAN

Measure Description

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

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

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left[\left(units_{baseline} \times \frac{lbf_{baseline}}{\left(\frac{lbf}{kW}\right)_{baseline}}\right) - \left(units_{ee} \times \frac{lbf_{ee}}{\left(\frac{lbf}{kW}\right)_{ee}} \times F_{VFD,ee}\right)\right] \times \frac{hrs}{1{,}000}$$

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
$units_{baseline}$		From application. For new installations, assume 5 x $units_{ee}$.[81]
$units_{ee}$		From application.
$lbf_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If unknown, or for new installations, use lbf_{ee} as the default value.
lbf_{ee}		From application.
$(lbf/kW)_{baseline}$		From application, look up from BESS Labs database based on manufacturer and model number. If not tested by BESS Labs, look up from Baseline Efficiencies section below based on fan diameter.
$(lbf/kW)_{ee}$		From application, look up from BESS Labs database based on manufacturer and model number or as rated by other third-party accredited laboratory
$F_{VFD,ee}$	No VFD: 1.00 VFD (Greenhouse): 0.64 VFD (Other): 0.75	Adjustment to efficient condition consumption to account for VFD control, based on presence of VFDs and fan application.[82]
hrs		From application. If unknown, look up from table below based on location for agricultural applications. For other C&I applications, assume fan operating hours align with the operating hours prescribed in the C&I Interior and Exterior Lighting measure found in this document, based on facility type.
CF	0.8	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.8.[83]

Baseline Efficiencies from which Energy Savings are Calculated

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

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

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

The baseline condition for this measure is a standard efficiency circulating fan. Baseline fan thrust (lbf) for circulating fans and fan efficiency shall come from application. If unavailable, look up from the table below based on fan type and diameter.[84]

Fan Diameter	Circulating Fans (lbf/kW)
24" – 35"	10.5
36" - 47"	12.9
48" - 52"	19.8
53"+	20.8

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

Operating hours shall come from application. If operating hours are unknown, the prescribed hours shall come from the lookup table below based on location for agricultural applications. Default hours are developed from NOAA hourly normals by summing annual hours dry bulb temperature is above 50ºF.[85]

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

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

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

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

Ancillary Electric Savings Impacts

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

References

1. Kammel, David & Raabe, & Kappelman, J.. (2003). Design of high volume low speed fan supplemental cooling system in dairy freestall barns. Proceedings of the Fifth International Dairy Housing Conference. 10.13031/2013.11628.
   Available from:
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Record of Revision

Record of Revision Number	Issue Date

3-20-9	3/30/2020
7-21-15	8/30/2021

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

ADVANCED RTU CONTROL

Measure Description

This measure covers the installation of advanced rooftop unit (RTU) control on a constant volume, rooftop HVAC unit with a single-speed supply fan. Advanced RTU control consists of integrated demand-controlled ventilation (DCV), a multi/variable-speed fan, and dual enthalpy control air-side economizers. DCV systems determine occupancy using a CO2 sensor and reduce heating and cooling loads by modulating outdoor air intake to meet ventilation requirements. Multi/variable-speed fan motors reduce the fan speed for first stage cooling and ventilation. Air-side economizers reduce mechanical cooling requirements by supplying outside air to the space when the outside air meets conditions deemed suitable for cooling.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{DCV} + \Delta kWh_{Econ}$$

$$\Delta kWh_{fan} = hp \times ESF_{fan} \times hrs$$

$$\Delta kWh_{DCV} = \frac{ft^2}{1{,}000} \times \left(\frac{\Delta kWh}{1000\ ft^2}\right)_{DCV,cool} + \frac{ft^2}{1{,}000} \times \left(\frac{\Delta kWh}{1000\ ft^2}\right)_{DCV,heat} \times F_{ElecHeat}$$

$$\Delta kWh_{Econ} = tons \times (\Delta kWh/\text{ton})_{Econ}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = hp \times ESF_{fan} \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = \frac{ft^2}{1{,}000} \times \left(\frac{\Delta MMBtu}{1000\ ft^2}\right)_{DCV} \times F_{FuelHeat}$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
ΔkWh_{fan}	= Annual electricity energy savings resulting from supply fan control
ΔkWh_{DCV}	= Annual electricity energy savings resulting from DCV
ΔkWh_{Econ}	= Annual electricity energy savings resulting from economizer
hp	= Horsepower of RTU supply fan
ESF_{fan}	= Energy savings factor for supply fan control (kWh/hp/hour)
hrs	= Annual operating hours of RTU supply fan

ft^2 = Total square footage of the conditioned space impacted by the measure
$(\Delta kWh/1{,}000ft^2)_{DCV,cool}$ = Energy savings factor for cooling (kWh/1,000 ft^2)
$(\Delta kWh/1{,}000ft^2)_{DCV,heat}$ = Energy savings factor for electric heating (kWh/1,000 ft^2)
$F_{ElecHeat}$ = Electric heating factor, used to account for the presence or absence of an electric heating system
tons = Tons of air conditioning supplied by RTU, based on nameplate data
$(\Delta kWh/ton)_{Econ}$ = Annual electric energy savings per ton of cooling
$(\Delta MMBtu/1{,}000ft^2)_{DCV}$ = Energy savings factor for heating (MMBtu/1,000 ft^2)
$F_{FuelHeat}$ = Fuel heating factor, used to account for the presence or absence of a fossil fuel heating system
1,000 = Conversion to 1,000 ft^2

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application
ESF_{fan}	0.580	Pacific Northwest National Laboratory.[86]
hrs		Lookup based on building type in Appendix A.
ft^2		From application
$(\Delta kWh/1{,}000ft^2)_{DCV,cool}$		Lookup from Electric Cooling Savings Associated DCV table below based on location and building type.
$(\Delta kWh/1{,}000ft^2)_{DCV,heat}$		Lookup from Electric Heating Savings with Heat Pump or Electric Heating Savings with Electric Resistance table below depending on electric heating type from application, based on location and building type.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
tons		From application
$(\Delta kWh/ton)_{Econ}$		Lookup based on building type and location in the Air Side Economizer table in Appendix J.
$(\Delta MMBtu/1{,}000ft^2)_{DCV}$		Lookup from Fuel Savings Associated with DCV table below based on location and building type.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise, use 0.0.

Unit energy savings associated with operation of an air-side economizer were calculated from a DOE-2.2 simulation of a series of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy savings by building type and city are shown in Appendix J.

Electric Cooling Savings Associated with DCV ($\Delta kWh/1{,}000ft^2$) [87]

[86] Unweighted average of kWh/hp/hour fan savings across all test cases in Advanced Rooftop Control (ARC) Retrofit: Field-Test Results, PNNL22656, Table 10: TMY weather normalized annual savings for all units. Fan Energy Savings (kWh) is divided by RTU Fan Power (hp) and Annual RTU Running Time (hr) to determine Energy Savings Factor for supply fan controls (kWh/hp/hr)

[87] Deemed savings calculated based on IL TRM values for Chicago, adjusted by the ratio of Cooling Degree Days for each listed NY city and Chicago, based on TMY3 data using base 65° balance point.

$(kWh/1{,}000\ ft^2)_{DCV,cool}$							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	205	131	187	125	398	230	196
Office - Mid-rise (4 to 11 Stories)	162	103	147	98	314	182	154
Office - High-rise (12+ Stories)	192	123	175	117	373	216	183
Religious Building	553	354	504	336	1,075	622	528
Restaurant	362	231	330	220	703	406	345
Retail - Department Store	279	178	254	169	541	313	266
Retail - Strip Mall	193	123	176	117	375	217	184
Convenience Store	253	162	231	154	492	284	242
Elementary School	260	167	237	158	506	292	248
High School	255	163	232	155	495	286	243
College/ University	302	193	275	184	587	339	288
Healthcare Clinic	251	161	229	153	488	282	240
Lodging (Hotel/Motel)	290	186	264	176	563	326	277
Manufacturing	125	80	114	76	244	141	120
Special Assembly Auditorium	412	264	375	250	800	463	393
Other	273	175	249	166	530	307	261
Enclosed Parking Garage	656	420	598	399	1,274	737	626

Electric Heating Savings with Heat Pump Associated with DCV ($\Delta kWh/1{,}000ft^2$) [88]

$(kWh/1{,}000\ ft^2)_{DCV,heat}$							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	216	233	214	265	151	201	215
Office - Mid-rise (4 to 11 Stories)	145	157	144	178	102	135	145
Office - High-rise (12+ Stories)	195	210	193	239	136	181	194
Religious Building	1,404	1,512	1,391	1,723	982	1,306	1,398
Restaurant	1,014	1,091	1,004	1,244	709	942	1,009
Retail - Department Store	347	373	343	425	242	322	345
Retail - Strip Mall	227	244	224	278	158	211	226
Convenience Store	172	185	170	211	120	160	171
Elementary School	603	649	597	739	421	560	600
High School	588	633	582	721	411	547	585
College/ University	1,174	1,264	1,163	1,440	821	1,091	1,169
Healthcare Clinic	417	449	413	512	292	388	415
Lodging (Hotel/Motel)	194	209	192	238	136	180	193
Manufacturing	120	129	119	147	84	112	120
Special Assembly Auditorium	1,648	1,774	1,632	2,022	1,152	1,532	1,641
Other	564	607	558	692	394	524	561

[88] Ibid

Electric Heating Savings with Electric Resistance Associated with DCV (ΔkWh/1,000ft^2) [89]

(kWh/1,000 ft^2)$_{DCV,heat}$							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	648	698	642	795	453	602	645
Office - Mid-rise (4 to 11 Stories)	435	469	431	534	304	405	433
Office - High-rise (12+ Stories)	584	629	578	716	408	543	581
Religious Building	4,213	4,537	4,174	5,170	2,946	3,917	4,195
Restaurant	3,041	3,274	3,012	3,731	2,126	2,827	3,028
Retail - Department Store	1,040	1,120	1,030	1,276	727	967	1,035
Retail - Strip Mall	681	733	674	835	476	633	678
Convenience Store	514	554	509	631	360	478	512
Elementary School	1,807	1,946	1,790	2,217	1,264	1,680	1,799
High School	1,763	1,898	1,746	2,163	1,233	1,639	1,755
College/ University	3,520	3,791	3,487	4,319	2,461	3,272	3,505
Healthcare Clinic	1,252	1,348	1,240	1,536	875	1,164	1,246
Lodging (Hotel/Motel)	581	625	575	712	406	540	578
Manufacturing	361	389	358	443	253	336	360
Special Assembly Auditorium	4,943	5,322	4,896	6,064	3,456	4,595	4,921
Other	1,692	1,822	1,676	2,076	1,183	1,573	1,685

Fuel Savings Associated with DCV (ΔMMBtu/1,000ft^2)[90]

(MMBtu/1,000 ft^2)$_{DCV}$							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	2.7	2.9	2.7	3.4	1.9	2.5	2.7
Office - Mid-rise (4 to 11 Stories)	1.9	2.0	1.9	2.3	1.3	1.8	1.9
Office - High-rise (12+ Stories)	2.5	2.7	2.5	3.1	1.8	2.4	2.5
Religious Building	18.0	19.4	17.8	22.1	12.6	16.7	17.9
Restaurant	13.0	14.0	12.8	15.9	9.1	12.0	12.9
Retail - Department Store	4.4	4.8	4.4	5.4	3.1	4.1	4.4
Retail - Strip Mall	3.0	3.2	2.9	3.6	2.1	2.7	2.9
Convenience Store	2.2	2.4	2.2	2.7	1.5	2.1	2.2
Elementary School	7.7	8.3	7.6	9.4	5.4	7.2	7.7
High School	7.5	8.1	7.4	9.2	5.2	7.0	7.4
College/ University	15.1	16.2	14.9	18.5	10.5	14.0	15.0
Healthcare Clinic	5.4	5.8	5.3	6.6	3.8	5.0	5.4
Lodging (Hotel/Motel)	2.4	2.6	2.4	3.0	1.7	2.3	2.4
Manufacturing	1.6	1.7	1.6	1.9	1.1	1.5	1.6
Special Assembly Auditorium	21.1	22.7	20.9	25.9	14.7	19.6	21.0
Other	7.2	7.7	7.1	8.8	5.0	6.7	7.1

[89] Ibid

[90] Deemed savings calculated based on IL TRM values for Chicago, adjusted by the ratio of Heating Degree Days for each listed NY city and Chicago, based on TMY3 data using base 65º balance point.

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.8. [91]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline case for this measure is a single zone, packaged rooftop HVAC unit with a single speed fan, and no occupancy-based ventilation or dual enthalpy economizer controls.

Compliance Efficiency from which Incentives are Calculated

The compliance case for this measure is the installation of an advanced rooftop controller consisting of a DCV system, multi or variable speed supply fan, and a dual enthalpy control air-side economizer on a single zone, packaged rooftop HVAC unit.

The efficient condition must comply with all applicable provisions of federal, state, local and municipal mechanical/ventilation and construction code, including but not limited to section C403.2.6.1 of ECCCNYS and section 402 of NYS Mechanical Code.

Operating Hours

HVAC system operating hours are embedded into the deemed savings shown in Appendix J 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

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. ECCCNYS 2020; C403.2.2 Ventilation
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2. NYSMC 2020 402 Natural Ventilation
   Available from: https://codes.iccsafe.org/content/NYSMC2020P1/chapter-4-ventilation

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

3. Advanced Rooftop Control (ARC) Retrofit: Field-Test Results, PNNL22656. U.S. Department of Energy, July 2013.
   Available from:
   https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf
4. $\Delta kWh/1{,}000ft^2$ and $\Delta MMBtu/1{,}000ft^2$ factors were calculated from the IL TRM Version 9.0, September 25, 2020, values of Chicago by creating a ratio of Cooling/Heating Degree Days between the NY weather cities and Chicago CDD/HDD and multiplying by the Chicago $SF_{cooling}/SF_{heating}$ respectively
   Available from: https://ilsag.s3.amazonaws.com/IL-TRM_Effective_010121_v9.0_Vol_2_C_and_I_09252020_Final.pdf

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7-20-13	7/31/2020
7-21-16	8/30/2021

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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.[92]

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 Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

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

[92] 10 CFR 431.306

ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
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
W_{EFan}	= Nameplate wattage of existing evaporator fan motor
F_{PA}	= Power adjustment 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
CF	= Coincidence factor
0.284	= Conversion factor from kW to Tons of refrigeration (Tons/kW)
1,000	= Conversion factor, one kW equals 1,000 W

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 Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel 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. [93]
hrs_{EFan}	On/Off Control: 5,571 Multistep Control: 6,062 No Cooler Control: 8,567	Based on refrigeration control type.[94]
hrs_{CM}	8,573	PG&E.[95]
F_{EFan}	0.65	Based on numerous pre and post meter readings conducted by NRM and supported by RLW Analytics evaluation.[96]
F_{CM}	Shaded Pole: 0.44 PSC: 0.3	US DOE.[97]
COP_{ref}		From application. If this information is unavailable, use default of 1.00 for Cooler and 1.92 for Freezer.[98] This default shall be used only in circumstances where manufacturer/nameplate data is missing, and facility staff is not able to provide it.

[93] Oak Ridge National Laboratory, Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits, September 2015, page 5.
[94] 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.
[95] PG&E Work Paper PGE3PREF124 Revision 2. Average of operating hours of medium temperature applications and low temperature applications.
[96] Small Business Services, Custom Measure Impact Evaluation, RLW Analytics, Inc., March 2007.
[97] 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.
[98] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect average efficiencies of systems using R-22, which was the

Variable	Value	Notes
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[99]

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.[100]

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

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

1. *Cooler Control Measure Impact Spreadsheet Users' Manual*, Select Energy Services,

most common refrigerant in active refrigeration systems in 2008 (per Analysis of Equipment and Practices in the Reclamation Industry, October 2010). Because this methodology applies to existing equipment manufactured prior to January 1, 2009, 2008 data is considered most pertinent for the purposes of this measure.

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

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

Inc. for NSTAR, March 9, 2004
2. Cadmus, Commercial Refrigeration Loadshape Project, October 2015
   Available from: https://neep.org/commercial-refrigeration-loadshape-report-10-2015-0
3. Small Business Services, Custom Measure Impact Evaluation, RLW Analytics, Inc. for National Grid, March 23, 2007
   Available from:
   https://library.cee1.org/system/files/library/8713/CEE_Eval_2007CustomMeasureImpactEvaluation_23Mar2007.pdf
4. 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
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/text-idx?SID=f7f8d64bb400ae3dc2d13f131cf116bb&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1446
7. 10 CFR 431.25 Energy conservation standards and effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=070fc8cd95943842a1e7a6f793d73496&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_125
8. US Department of Energy, Commercial Refrigeration Equipment (CRE) Technical Support Document
   Available from:
   https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cre2_nopr_tsd_2013_08_28.pdf
9. Oak Ridge National Laboratory, Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits, September 2015
   Available from: https://info.ornl.gov/sites/publications/files/Pub58600.pdf
10. Pacific Gas & Electric Company, Work Paper PGE3PREF124 Display Case ECM Motor Retrofit, Revision #2, April 2014
    Available from: http://www.deeresources.net/workpapers

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-17	7/31/2013
9-17-9	9/30/2017
9-18-15	9/28/2018

12-19-15	12/23/2019
7-21-20	8/30/2021

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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[101]
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[102]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[103]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[104]
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[105]
	Advanced Power Strip (APS)	Residential	8	DEER 2014 EUL ID: Plug-OccSens
Appliance Control	Air Conditioner - Room (RAC) Recycling	Residential	3	DEER 2014 EUL ID: HV-RAC-RUL

[101] 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
[102] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[103] ENERGY STAR® Dehumidifier Calculator
https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[104] 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
[105] 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
Appliance Recycling	Dehumidifier Recycling	Residential	3	Assumes same RUL as RAC
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef
	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr
	Air Conditioner – Room (RAC) Cover and Gap Sealer	Residential	3	See note below[106]
Building Shell	Air Leakage Sealing	Residential	15	GDS[107]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[108]
	Insulation – Opaque Shell	Residential	25	GDS[109]
	Storm Window	Residential	20	DOE[110]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
	Window - Film	Residential	10	DEER 2014 EUL ID: GlazDaylt-WinFilm
	Heat Pump Water Heater (HPWH)	Residential	10	DEER 2014 EUL ID: WtrHt-HtPmp
Domestic Hot Water (DHW)	Indirect Water Heater	Residential	11	DEER 2014 EUL ID: WtrHt-Res-Gas
	Storage Water Heater - Gas	Residential	15	PA Consulting Group[111]
	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[112]

[106] Average/typical manufacturer warranty period for AC covers
[107] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[108] Ibid.
[109] Ibid.
[110] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[111] 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
[112] https://www.energy.gov/energysaver/solar-swimming-pool-heaters

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
DHW - Control	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[113]
	Air Conditioner – Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner – Room (RAC)	Residential	12	GDS[114]
	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[115]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER 2014[116] 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

[113] 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.
[114] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[115] 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
[116] Based on DEER value for high efficiency boiler and instantaneous water heater

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Energy and Heat Recovery Ventilator	Residential	14	PA Consulting Group[117]
	Furnace, Gas Fired	Residential	22	DOE[118,119]
	Gas Heat Pump	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[120]
	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
	Adaptive Photonic Control	Residential	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
HVAC - Control	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A

[117] 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

[118] 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

[119] 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

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
HVAC - Control	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[121]
	Thermostat – All Types	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[122]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[123]
	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[124]
Lighting	LED Lamp Light Fixture	Residential LED (Interior)	50,000 hours	DLC[125]
			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

[121] NYSERDA Residential Electric Submetering Manual
[122] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. pg. 16
[123] Based on assumed EUL of integrated fan, which is expected to be the first component to fail
[124] 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
[125] 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 Bi-Level Lighting	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[126]
		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
		Multifamily Common Area	15	ComEd[127]	ENERGY STAR® Fixtures
Lighting Control	Pool Pump		Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Motors and Drives	Pool Circulator Timer		Residential	10	DEER 2014 EUL ID: OutD-PoolPump
	Heat Pump Pool Heater		Residential	15	DEER 2014 EUL ID: HV-Res HP
Other	Pool Heater		Residential	8	DOE[128]
	Solar Pool Heater		Residential	15	DOE[129]

[126] 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
[127] 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
[128] 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
[129] https://www.energy.gov/energysaver/solar-swimming-pool-heaters

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment	High Speed Fans	C&I	10	PG&E[130]
	Milk Pre-Cooler Heat Exchanger	C&I	15	PA Consulting Group[131]
	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[132]
	Variable Speed Drive Milk Pump Plate Cooler	C&I	15	PA Consulting Group[133]
	Variable Speed Drive Vacuum Pump	C&I	15	PA Consulting Group[134]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[135]
	Clothes Washer	C&I	11	DEER 2014 EUL ID: Appl-EffCW
	Cooking Equipment[136]	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[137]
	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

[130] PG&E Work Paper PGE3PAGR117, October 12, 2017
[131] 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
[132] Based on EUL's for Advanced Power Strips
[133] 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
[134] 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
[135] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[136] Applicable to all kitchen cooking equipment not otherwise listed
[137] 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
Appliance Recycling	Air Conditioner – Room (RAC)	C&I	9	DEER 2014 EUL ID: HV-RAC-ES
Building Shell	Air Leakage Sealing	C&I	15	GDS[138]
	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[139]
	Insulation - Opaque Shell	C&I	30	ET & CEC[140]
	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[141]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[142]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study[143]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [144]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [145]
	Flow Controller	C&I	13	Other State TRMs [146]
	Low Pressure Drop Filter	C&I	5	Other State TRMs [147]
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

[138] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[139] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[140] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[141] 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.
[142] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[143] 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
[144] 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.
[145] Ibid.
[146] Ibid.
[147] Ibid.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
DHW - Control	Drain Water Heat Recovery (DWHR)	C&I	30	2019 Title 24[148]
	Low-Flow – Faucet Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Pre-Rinse Spray Valve (PRSV)	C&I	5	GDS
	Low-Flow – Salon Valve	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Low-Flow – Showerhead	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Central DHW Control	C&I	15	NREL[149]
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[150]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER 2014[151] 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[152]
	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

[148] 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

[149] https://www.nrel.gov/docs/fy16osti/64541.pdf

[150] 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

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

[152] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	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[153,154]
	Gas Heat Pump	C&I	15	DEER 2014 EUL ID: HV-Res HP
	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[155]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[156]
	Infrared Heater	C&I	17	GDS[157]
	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[158]
	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

[153] 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

[154] 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

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

[156] 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

[157] 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

[158] 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	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
	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[159]
	Kitchen Demand Ventilation Control	C&I	15	PG&E[160]
	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[161]
	Advanced Rooftop Control	C&I	EUL = RUL of Existing RTU = RTU EUL – (Current Year – Year of Mfr.) **Default = 5**	N/A

[159] 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
[160] PG&E Work Paper WPSDGENRCC0019, June 15, 2012
[161] 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[162]
	Light Fixture	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®[163]
		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®[164]
		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®[165]
		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

[162] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4

[163] 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

[164] 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

[165] 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[166]
			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[167]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[168]
	Integrated Interior Lighting Control	C&I	15	ComEd[169]
	Non-Integrated Interior Lighting Control	C&I	10	GDS[170]
	Plug-Load Occupancy Sensor	C&I	8	DEER[171]
Motors and Drives	Motor (incl. PEI Pumps)	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[172]

[166] 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

[167] 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

[168] 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

[169] 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

[170] 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

[171] DEER value for lighting occupancy sensors

[172] Assumes same EUL as VFD measure.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Other	Heat Pump Pool Heater	C&I	15	DEER 2014 EUL ID: HV-Res HP
	High Efficiency Transformer	C&I	32	DOE[173]
	High Frequency Battery Charger	C&I	15	PG&E[174]
	High Viscosity Industrial Lubricant	C&I	10	ExxonMobil
	Pool Heater	C&I	8	DOE[175]
	Solar Pool Cover	C&I	5	CALMAC[176]
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Ozone Laundry	C&I	10	PG&E[177]
	Process Exhaust Filtration	C&I	15	CIBSE[178]
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
	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

[173] https://www.federalregister.gov/documents/2019/06/18/2019-12761/energy-conservation-program-energy-conservation-standards-for-distribution-transformers
[174] https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf, pg 43
[175] 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
[176] http://www.calmac.org/publications/PoolCoverReport_2015_Final_Report_Appendices.pdf
[177] PG&E Work Paper PGECOAPP123, August 22, 2017
[178] 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.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
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 [179]

Common References

1. DEER 2014 EUL
   Available from:
   http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx
2. GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007
   Available from:
   https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

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

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

Record of Revision Number	Issue Date
12-19-17	12/23/2019
3-20-17	3/30/2020
7-20-20	7/31/2020
12-20-12	12/31/2020
3-21-18	3/31/2021
7-21-21	8/30/2021

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DOMESTIC HOT WATER – CONTROL

LOW-FLOW - SHOWERHEAD

Measure Description

This measure covers the installation of low-flow showerheads. A low-flow showerhead is a water saving showerhead with rated gallons per minute (gpm) less than maximum allowable flowrate as mandated by federal, state, local and municipal codes and standards. Energy savings are realized through the decreased demand for hot water during shower use. New York State plumbing code[180] prescribes a maximum flowrate of 2.0 gpm for showerheads. This is a retrofit direct install measure or a new installation in a residential application.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Water Heating Only)

$$\Delta kWh = units \times H_2O_{savings} \times (T_{shower} - T_{main}) \times \frac{8.33}{3{,}412} \times \frac{1}{UEF}$$

Summer Peak Coincident Demand Savings (Electric Water Heating Only)

$$\Delta kW = Negligible$$

Annual Fuel Energy Savings (Fuel Water Heating Only)

$$\Delta MMBtu = units \times H_2O_{savings} \times (T_{shower} - T_{main}) \times \frac{8.33}{1{,}000{,}000} \times \frac{1}{UEF}$$

Note: to estimate the annual gallons of water saved from installation of measure:

$$H_2O_{savings} = (GPM_{baseline} - GPM_{ee}) \times Throttle_{fac} \times \frac{1}{\mathrm{F}_{shower}} \times \frac{minutes}{use} \times \frac{uses}{person/day} \times \frac{person}{household} \times 365$$

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
$H_2O_{savings}$	= Water savings
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
GPM	= Gallon per minute
$Throttle_{fac}$	= Throttle factor

[180] 2020 NYS Plumbing Code, Table 604.4

F_{shower} = Shower Factor
T_{shower} = Temperature (^oF) at showerhead
T_{main} = Temperature (^oF) of supply water from main
UEF = Uniform Energy Factor
8.33 = Energy required (BTU), to heat one gallon of water by one degree Fahrenheit
365 = Days in one year
3,412 = Conversion factor, one kW equals 3,412 BTU/h
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		Gallons per minute for energy efficient measure, from application
$GPM_{baseline}$		For LMI projects, flowrate shall come from application or default to 2.5 GPM.[181] Otherwise, use 2.0 GPM.[182]
$Throttle_{fac}$	0.9	Used in LBNL study to adjust for average percent of full capacity that the shower valve is opened when in use[183]
F_{shower}	1.4	Factor capturing average number of showers per household[184]
minutes/use	8.2	Average shower duration per LBNL study.[185]
uses/person/day	0.75	LBNL showers per day per capita.[186]
person/ household		Persons per household, from application. If unknown, use 2.8 for Single Family[187] and 2.0 for Multifamily[188]. If housing type is unknown, use 2.4.[189]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
T_{shower}	104	Average temperature at showerhead[190]

[181] The Energy Policy Act (EPAct) of 1992 (https://afdc.energy.gov/files/pdfs/2527.pdf)
[182] 2020 NYS Plumbing Code, Table 604.4
[183] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[184] United States Census Bureau, American Housing Survey – Table Creator, New York, 2017, Housing Unit Characteristics. The shower factor was calculated by taking the average number of complete bathrooms per household. Granularity at the single vs. multifamily level was not available.
[185] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[186] Ibid.
[187] Residential Statewide Baseline Study of New York State, July 2015. Volume 1: Single-Family Report, Table 9
[188] Residential Statewide Baseline Study of New York State, July 2015. Volume 2: Multifamily Report, Table 8
[189] Unweighted average between single- and multifamily buildings
[190] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014

Variable	Value	Notes
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern)[191]

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[192] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[193] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The Summary of Variables and Data Sources provides the baseline (standard) water flow and related input assumptions. Assumptions regarding average duration of use and number of uses per day are also presented. Uniform Energy Factor (UEF) is determined for the assumed water heater system configurations cited per the table below (from Code of Federal Regulations 10 CFR 430.32(d)).

UEF shall be calculated as a function of existing equipment tank volume (V_t) with the appropriate equation, looked up based on existing equipment type, capacity and draw pattern. Draw pattern can be established based on the existing equipment First Hour Rating (FHR), rated in gallons; see the First Hour Rating vs. Draw Pattern table below.

If FHR is unknown, a Medium draw pattern should be assumed for storage type water heaters with rated storage capacity ≤ 50 gallons and a High draw pattern should be assumed otherwise.[194] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a

[191] 10 CFR 430.32(d); medium draw pattern default assumption based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[192] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[193] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals
[194] Based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)

40-gallon rated storage volume, Medium draw storage type system with primary water heater fuel from application.

Residential Water Heaters

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.3456 - (0.0020 \times V_r^*)$
		Low	$0.5982 - (0.0019 \times V_r)$
		Medium	$0.6483 - (0.0017 \times V_r)$
		High	$0.6920 - (0.0013 \times V_r)$
	> 55 gal and ≤ 100 gal	Very Small	$0.6470 - (0.0006 \times V_r)$
		Low	$0.7689 - (0.0005 \times V_r)$
		Medium	$0.7897 - (0.0004 \times V_r)$
		High	$0.8072 - (0.0003 \times V_r)$
Oil-Fired Storage Water Heater	≤50 gal	Very Small	$0.2509 - (0.0012 \times V_r)$
		Low	$0.5330 – (0.0016 \times V_r)$
		Medium	$0.6078 – (0.0016 \times V_r)$
		High	$0.6815 - (0.0014 \times V_r)$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.8808 - (0.0008 \times V_r)$
		Low	$0.9254 - (0.0003 \times V_r)$
		Medium	$0.9307 - (0.0002 \times V_r)$
		High	$0.9349 - (0.0001 \times V_r)$
	> 55 gal and ≤ 120 gal	Very Small	$1.9236 - (0.0011 \times V_r)$
		Low	$2.0440 - (0.0011 \times V_r)$
		Medium	$2.1171 - (0.0011 \times V_r)$
		High	$2.2418 - (0.0011 \times V_r)$
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*V_t = Rated Storage Volume (gal)

First Hour Rating vs. Draw Pattern[195]

First Hour Rating	Draw Pattern
< 18 gallons	Very Small
≥ 18 and < 51 gallons	Low
≥ 51 and < 75 gallons	Medium
≥ 75 gallons	High

Compliance Efficiency from which Incentives are Calculated

[195] 10 CFR 429.17

Compliance flow rate is less than the specified baseline value (<2.0 gpm) or less than the more restrictive codes or guidelines of local governments, municipalities or entities which, for example, participate in the US EPA Water Sense® Partnership Program. [196]

Operating Hours

Estimate of energy savings assumes an average duration of 8 minutes, 12 seconds per shower event, 0.75 showers per person per day, and 2.8 persons per single family home and 2.0 persons per multifamily home.

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. NYS Plumbing Code, 2020; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
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Record of Revision

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0	10/15/2010
6-13-4	6/30/2013
6-15-1	6/15/2015
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3-19-7	3/29/2019
6-19-6	6/28/2019
7-21-22	8/30/2021

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTATIC RADIATOR VALVE (TRV) – ONE PIPE STEAM RADIATOR

Measure Description

This measure covers the installation of thermostatic radiator valves (TRVs) on one-pipe steam radiators. TRVs are self-contained, self-operated valves that do not require ancillary power. They provide local control of room temperature by controlling the venting of air out of the radiator. TRVs are available for a variety of installation conditions utilizing either remote-mounted sensors or integral-mounted sensors by means of remote or integral set point adjustment. This measure is specifically a TRV in combination with an air vent installed at one or more radiators in a one-pipe steam space heating system.

TRVs demonstrate the greatest potential for energy savings and financial viability when overheating is exhibited in zones throughout the system and when combined with other steam system best practices improvements. Therefore, prioritization of this measure is recommended in zones that are overheated by 3°F or greater[197] and when installed as part of system inspection, balancing and commissioning including, but not limited to: burner tuning, boiler cleaning, recalibration of boiler control set points, inspection and repair/replacement of leaking inlets and air vents, installation of properly sized air vents, main line steam trap repair/replacement, recalibration of system operating pressure, insulation of bare steam lines and installation of radiator orifice plates in two-pipe systems.[198]

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

$$\Delta MMBtu = units \times (\Delta MMBtu/HDD) \times HDD_{loc}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of TRVs installed
(ΔMMBtu/HDD)	= Annual fuel energy savings per Heating Degree Day (HDD), per TRV

[197] NYSERDA, Thermostatic Radiator Valve (TRV) Demonstration Project, Report No. 95-14, September 1995, pg. 5-1

[198] US DOE, Thermostatic Radiator Valve Evaluation, January 2015, pg. 25 - 26

HDD_{loc} = Heating Degree Days based on location

Summary of Variables and Data Sources

Variable	Value	Notes
ΔMMBtu/HDD	0.0004318	Average fuel savings per HDD per unit[199]
HDD_{loc}		Lookup based on location from Heating Degree Days section below

Heating Degree Days

For the purposes of this measure, Heating Degree Days are defined as the number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The HDD values listed in the table below are based on 30-year averages of U.S annual climate normals for the period of 1981 to 2010 using base 65° F.[200]

City	HDD_{loc}
Albany	6,680
Binghamton	7,193
Buffalo	6,617
Massena	8,196
NYC	4,671
Poughkeepsie	6,210
Syracuse	6,651

Coincidence Factor (CF)

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

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is an existing space heating system with manual control valves at freestanding radiators, convectors, or baseboard heating units.

Compliance Efficiency from which Incentives are Calculated

The measure is defined as the existing radiator, convector, or baseboard heater unit controlled by the thermostatic radiator valve.

[199] Thermostatic Radiator Valve (TRV) Demonstration Project. Prepared by NYSERDA, Project Manager Norine Karins and the EME Group Project Manager Michael McNamara. NYSERDA report 95-14. September 1995.
[200] HDD taken from NCEI 1981-2010 climate normals

Operating Hours

Evaluation of savings associated with installation of TRVs is dependent upon typical heating degree days as specified in the Summary of Variables and Data Sources above.

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.

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