## Table of Revisions/Changes

| Revision Number | Addition/ Revision | Issue Date | Effective Date | Measure | Description of Change | Location/Page in TRM |
|---|---|---|---|---|---|---|
| 6-19-4 | R | 6/28/2019 | 1/1/2021 | R/MF Refrigerator and Freezer Recycling | Updated Measure Description to clarify incorporation of the part-time adjustment factor; Added detail to Summary of Variables and Data Sources on the consistency of the evaluation with UMP protocol | Pg. 44 |
| 6-19-5 | R | 6/28/2019 | 1/1/2021 | R/MF Low-Flow – Faucet Aerator | Added detail to Measure Description; Changed Summer Peak Coincident Demand Savings from N/A to Negligible; Revised algorithm, variable terms, definitions, and default values to consider persons/household and faucets/household with delineation between single and multi-family homes; Updated Throttle factor; Updated faucet temperature with delineation between lavatory and non-lavatory applications; Added detail to Operating Hours | Pg. 100 |
| 6-19-6 | R | 6/28/2019 | 1/1/2021 | R/MF Low-Flow – Showerhead | Added detail to Measure Description; Changed Summer Peak Coincident Demand Savings from N/A to Negligible; Revised algorithm, variable terms, definitions, and default values to consider persons/household and showerheads/household with delineation between single and multi-family homes; Updated shower temperature; Added detail to Operating Hours | Pg. 105 |
| 6-19-7 | R | 6/28/2019 | 1/1/2021 | R/MF Thermostatic Shower Restriction Valve | Modified Measure Description; Changed Summer Peak Coincident Demand Savings from N/A to Negligible; Revised algorithm, variable terms, definitions, and default values to consider persons/household and showerheads/household with delineation between single and multi-family homes; Rearranged Summary of Variables and Data Sources section for clarity | Pg. 110 |

| Revision Number | Addition/ Revision | Issue Date | Effective Date | Measure | Description of Change | Location/Page in TRM |
|---|---|---|---|---|---|---|
| 6-19-8 | R | 6/28/2019 | 1/1/2021 | R/MF Thermostatic Radiator Valve (TRV) – One Pipe Steam Radiator | Added language to Measure Description regarding recommended application of measure as outlined by DOE | Pg. 190 |
| 6-19-9 | R | 6/28/2019 | 1/1/2021 | C/I Air Compressor | Updated Measure Description to clarify functionality of control type options; Updated unit savings values and source; Removed inlet modulating as baseline compressor type | Pg. 284 |
| 6-19-11 | R | 6/28/2019 | 1/1/2021 | C/I Interior Lighting Controls | Added language to Measure Description regarding application and code compliance; Updated Energy Savings Factor values and sources and added control type options and associated savings and definitions; Added requirement for Networked Lighting Control to be compliant with DLC requirements | Pg. 448 |
| 6-19-14 | R | 6/28/2019 | 1/1/2021 | Appendix P | Updated EUL entries for all measures contained in this Record of Revision | Pg. 765 |
| 6-19-15 | R | 6/28/2019 | 1/1/2021 | Glossary | Added entries to align with all measures contained in this Record of Revision | Pg. 778 |

**Note:** Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between March 29, 2019 – June 28, 2019.

## REFRIGERATOR AND FREEZER RECYCLING

### Measure Description

In many cases, when a refrigerator or freezer is replaced by a homeowner, the existing unit is retained, sold or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of the existing, functional equipment, thereby eliminating the consumption associated with that equipment. Refrigerator and freezer recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing inefficient, functional refrigerators and freezers from the electric grid.

This measure covers the recycling of primary (i.e. installed in a kitchen) and secondary (i.e. installed elsewhere) refrigerators, refrigerator-freezers and freezers. To account for the fact that secondary equipment is occasionally installed and operating for only part of the year, a part-time use adjustment factor has been developed and embedded within the gross savings estimate for secondary units to establish average annual per unit deemed electric savings.

This measure does not cover the recycling of equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer". This refers to any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 $ft^3$ (220 liters), where the total refrigerated volume has been determined in accordance with the procedure prescribed in Appendix A (refrigerators and refrigerator-freezers) or B (freezers) of 10 CFR 430 Subpart B.[1]

### Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

*Annual Electric Energy Savings*

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

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \Delta kWh/8{,}760 \times TAF \times LSAF \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

**where:**

| | |
|---|---|
| ΔkWh | = Annual electric energy savings |
| ΔkW | = Peak coincident demand electric savings |
| Δtherms | = Annual gas energy savings |
| units | = Number of measures recycled under the program |
| (ΔkWh/unit) | = Gross deemed annual electric savings per unit |
| TAF | = Temperature Adjustment Factor |
| LSAF | = Load Shape Adjustment Factor |

[1] 10 CFR 430.2

CF = Coincidence Factor
8,760 = Hours in one year

**Summary of Variables and Data Sources**

There are several conditions that impact the estimated savings available from a refrigerator and/or freezer-recycling program. Factors such as the average type, make, model, size, and age of units recycled significantly impact the savings. Variances in these conditions have a significant impact of the level of savings that can be achieved. In addition, the average number of hours these units are plugged in and operating impact savings. Likewise, the environmental and operational conditions also impact the energy savings. These variables make establishing a projected engineering-based calculation approach for per unit savings a complex task that is prone to error because of the effects of the compounding uncertainty associated with the potential variance within each of the key estimation variables. However, savings projections in this measure are based on impact evaluations completed in New York State conducted in compliance with the National Renewable Energy Laboratory's Uniform Methods Project (UMP) Refrigerator Recycling Evaluation Protocol.[2]

The following deemed energy impact estimates shall be used in New York for refrigerator and freezer recycling programs.

| Variable | Value | Notes |
|---|---|---|
| (ΔkWh/unit) | Primary Refrigerator: 1,218<br>Secondary Refrigerator: 794<br>Freezer: 846 | Refrigerator based on Cadmus memo to Consolidated Edison. [3]<br>Freezer based on Energy & Resource Solutions[4] |
| TAF | 1.22 | Temperature Adjustment Factor; reflects load variance during summer peak due to increased ambient temperature conditions.[5] |
| LSAF | 1.06 | Load Shape Adjustment Factor; reflects the instantaneous differential from annual average load coincident with peak.[6] |
| CF | 1.0 | |

[2] NREL, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. January 2010-September 2016. Chapter 7: Refrigerator Recycling Evaluation Protocol
[3] Cadmus memo to Consolidated Edison, "Recommended Gross Savings Values for Refrigerator Recycling Programs", December 17, 2015
[4] Based on Energy & Resource Solutions "Con Edison EEPS Programs - Impact Evaluation of Residential Appliance Bounty Program", May 2015. Filed under Item Number 3788. Gross unit consumption of 1,267 kWhs x part use factor of 0.685 = 846 kWhs
[5] Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004. It assumes 58% of New York homes have central air conditioning.
[6] Ibid.

### Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[7]

### Baseline Efficiencies from which Energy Savings are Calculated

The savings calculations above apply to recycling of a functioning primary[8] or secondary refrigerator, refrigerator-freezer or freezer with total refrigerated volume of 7.75 $ft^3$ (220 liters) or more.

### Compliance Efficiency from which Incentives are Calculated

The compliance condition is the recycling of an existing room refrigerator or freezer as defined in the Measure Description section above.

### Operating Hours

Primary refrigerators or freezers are assumed to be connected to an electrical outlet 8,760 hours per year. Secondary units may only be connected part-time, but 8,760 hours per year is utilized in these cases as well for the sake of establishing conservative estimates of Summer Peak Coincident Demand Savings.

### 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. 10 CFR 430.2 Definitions.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=433d4d2525eac3e38a1ede79f3b5c0ed&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12

[7] *No source specified – update pending availability and review of applicable references*
[8] Savings can be claimed for recycling a primary refrigerator as long as savings for that replacement were not claimed by another energy efficiency program.

2. NREL, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. January 2010-September 2016. Chapter 7: Refrigerator Recycling Evaluation Protocol.
   Available from: https://www.nrel.gov/docs/fy18osti/70472.pdf
3. Cadmus memo to Consolidated Edison, "Recommended Gross Savings Values for Refrigerator Recycling Programs", December 17, 2015
4. Con Edison EEPS Programs – Impact Evaluation of Residential Appliance Bounty Program, Energy & Resource Solutions (ERS), filed under Item Number 3788, May 4, 2015
   Available from:
   http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=07-m-0548&submit=Search
5. Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004
   Available from: https://nascsp.org/wp-content/uploads/2018/02/blasnik_measurement-and-verification-of-residential-refrigerator.pdf
6. National Renewable Energy Laboratory, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 7: Refrigerator Recycling Evaluation Protocol, April 2013.
   Available from: https://www.energy.gov/sites/prod/files/2013/05/f0/53827-7.pdf

**Record of Revision**

| Record of Revision Number | Issue Date |
|---|---|
| 2 | 10/15/2010 |
| 7-13-4 | 7/31/2013 |
| 9-13-2 | 9/2/2013 |
| 6-15-2 | 6/1/2015 |
| 12-17-2 | 12/31/2017 |
| 6-19-4 | 1/1/2021 |
| | |

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## *DOMESTIC HOT WATER – CONTROL*

### LOW-FLOW - FAUCET AERATOR

**Measure Description**

This measure covers the installation of low-flow aerators on residential faucets. A low-flow faucet aerator is a water saving device 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 faucet use. New York City plumbing code[1] and New York State construction code[2] dictate a maximum flowrate of 1.5 gpm for lavatory faucets and 2.2 gpm elsewhere. 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)*

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

*Summer Peak Coincident Demand Savings (Electric Water Heating Only)*

$$\Delta kW = Negligible$$

*Annual Gas Energy Savings (Gas Water Heating Only)*

$$\Delta therms = units \times H_2O_{savings} \times \Delta T_{main} \times \frac{8.33}{100{,}000} \times \frac{1}{UEF}$$

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

$$H_2O_{savings} = \left(GPM_{baseline} \times Throttle_{fac,baseline} - GPM_{ee} \times Throttle_{fac,ee}\right) \times \frac{1}{\mathrm{F}_{faucet}} \times \frac{minutes}{person/day} \times \frac{person}{household} \times 365$$

**where:**

| | |
|---|---|
| ΔkWh | = Annual electric energy savings |
| ΔkW | = Peak coincident demand electric savings |
| Δtherms | = Annual gas energy savings |
| units | = Number of measures installed under the program |
| $H_2O_{savings}$ | = Water savings (gallons/day) |

[1] 2017 NYS Uniform Code Supplement, Table P2903.2
[2] 2014 NYC Plumbing Code, Table 604.4

$\Delta T_{main}$ = Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F)
UEF = Uniform Energy Factor
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
GPM = Gallon per minute
$Throttle_{fac}$ = Throttle factor
$F_{faucet}$ = Faucets per household factor
8.33 = Energy required (BTU's), 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
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

**Summary of Variables and Data Sources**

| Variable | Value | Notes |
|---|---|---|
| $GPM_{baseline}$ | Non-lavatory: 2.2<br>Lavatory: 1.5 | GPM for baseline measure, based on faucet type[3,4] |
| $Throttle_{fac,baseline}$ | 0.83 | American Council for an Energy-Efficient Economy[5] |
| $GPM_{ee}$ | Non-lavatory: 1.5<br>Lavatory: 1.0 | From application. If unknown, assume minimum flow rates for compliance. |
| $Throttle_{fac,ee}$ | 0.95 | American Council for an Energy-Efficient Economy[6] |
| $F_{faucet}$ | Non-lavatory: 1<br>Lavatory: 1.6 | Factor reflecting the number of faucets in an average New York household[7] |
| minutes/ person/day | Non-lavatory: 4.5<br>Lavatory: 1.6 | Metered water consumption based on faucet type[8] |
| person/ household | Single family: 2.8<br>Multi-family: 2.0 | Persons per household, based on housing type[9,10] |
| $H_2O_{savings}$ | Non-lavatory, SF: 1,844<br>Non-lavatory, MF: 1,317<br>Lavatory, SF: 301<br>Lavatory, MF: 215 | Calculated gallons of water saved per year based on default values of installation of energy efficient measure, from application |

[3] 2017 NYS Uniform Code Supplement, Table P2903.2
[4] 2014 NYC Plumbing Code, Table 604.4
[5] Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008, pg. 1-265
[6] Ibid
[7] American Housing Survey Table Creator, United States Census Bureau, Housing Unit Characteristics, New York 2017. The lavatory faucet factor was calculated by taking the average number of complete or half bathrooms per household.
[8] Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study. June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015, Table 93
[9] Residential Statewide Baseline Study of New York State, July 2015. Volume 1: Single-Family Report, Table 9
[10] Residential Statewide Baseline Study of New York State, July 2015. Volume 2: Multifamily Report, Table 8

| Variable | Value | Notes |
|---|---|---|
| $\Delta T_{main}$ | $T_{faucet} - T_{main}$ | Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F). |
| $T_{faucet}$ | Non-Lavatory: 93<br>Lavatory: 86<br>Unknown: 88 | Faucet operating temperature (°F)[11]. Unknown is derived from the calculated weighted average based on statewide average assumptions: ((1*93)+(3*86))/(1+3)= 88 |
| $T_{main}$ | | Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city. |
| UEF | See UEF Table Below | Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern)[12] |

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.[13] Supply main temperatures based on the annual outdoor temperature are shown below.

| City | Annual average outdoor temperature[14] (°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) and low flow aerator water flows, related input assumptions, and the resulting water savings. Assumptions regarding average duration of use and number of uses per day are also presented. Uniform Energy Factor is

[11] Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study. June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015, Table 93

[12] 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)

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

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

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.[15] If the type of existing water heater cannot be identified due to program delivery mechanism, assume 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 | Uniform Energy Factor |
|---|---|---|---|
| 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 $V_t$) |
| 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 $V_t$) |
| | > 55 gal and ≤ 100 gal[16] | 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 $V_t$) |
| 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 |

[15] Based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[16] For informational purposes only: UEF values for electric storage water heaters > 55 gallons and ≤ 100 gallons imply this equipment heat pump water heaters

| Product Class | Rated Storage Volume and Input Rating | Draw Pattern | Uniform Energy Factor |
|---|---|---|---|
| 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[17]

| 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

The compliance condition is a lavatory faucet aerator with a flowrate of 1.0 GPM or less or a non-lavatory faucet aerator with a flowrate of 1.5 GPM or less.

### Operating Hours

Non-lavatory faucet aerators are assumed to be in use 4.5 minutes per day per person and lavatory faucets are assumed to be in use 1.6 minutes per day per person. All faucet aerators are assumed to be available 365 days per year.

### Effective Useful Life (EUL)

See Appendix P.

### Ancillary Fossil Fuel Savings Impacts

N/A

### Ancillary Electric Savings Impacts

N/A

### References

1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf

[17] 10 CFR 429.17

2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from:
   http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Energy-related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008
   Available from: http://www.seattle.gov/light/conserve/reports/paper_10.pdf
4. Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study. June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015
   Available from: http://www.oracle.com/us/industries/utilities/cadmus-indianapolis-power-light-3697534.pdf%20
5. United States Census Bureau, American Housing Survey – Table Creator, New York, 2017, Housing Unit Characteristics
   Available from: https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html#?s_areas=a00036&s_year=s2017&s_tableName=Table0&s_byGroup1=a1&s_byGroup2=a1&s_filterGroup1=t1&s_filterGroup2=g1&s_show=S
6. Residential Statewide Baseline Study of New York State, July 2015.
   Available From:
   https://www.nyserda.ny.gov/About/Publications/Building%20Stock%20and%20Potential%20Studies/Residential%20Statewide%20Baseline%20Study%20of%20New%20York%20State
7. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
8. 10 CFR 429.17 Water heaters.
   Available from: : https://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=10:3.0.1.4.17#se10.3.429_117
9. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
10. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
    Available from:
    http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf
11. AHRI Directory of Certified Product Performance
    Available from: https://www.ahridirectory.org/ahridirectory/pages/home.aspx

**Record of Revision**

| Record of Revision Number | Issue Date |
|---|---|
| 1 | 10/15/2010 |
| 6-13-5 | 6/30/2013 |
| 7-13-7 | 7/31/2013 |
| 6-17-2 | 6/30/2017 |
| 3-19-5 | 3/29/2019 |
| 6-19-5 | 1/1/2021 |
| | |

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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 City plumbing code[1] and New York State construction code[2] dictate 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 Gas Energy Savings (Gas Water Heating Only)*

$$\Delta therms = units \times H_2O_{savings} \times (T_{shower} - T_{main}) \times \frac{8.33}{100{,}000} \times \frac{1}{UEF}$$

**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 |
| Δtherms | = Annual gas 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 |

[1] 2017 NYS Uniform Code Supplement, Table P2903.2
[2] 2014 NYC Plumbing Code, Table 604.4

GPM = Gallon per minute
$Throttle_{fac}$ = Throttle factor
$F_{shower}$ = Shower Factor
$T_{shower}$ = Temperature (°F) at showerhead
$T_{main}$ = Temperature (°F) of supply water from main
UEF = Uniform Energy Factor
8.33 = Energy required (BTU's), 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
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

**Summary of Variables and Data Sources**

| Variable | Value | Notes |
|---|---|---|
| $GPM_{ee}$ | | Gallons per minute for energy efficient measure, from application |
| $GPM_{baseline}$ | 2.0 | Gallons per minute for baseline[3,4] |
| $Throttle_{fac}$ | 0.9 | Used in LBNL study to adjust for average percent of full capacity that the shower valve is opened when in use[5] |
| $F_{shower}$ | 1.4 | Factor capturing average number of showers per household[6] |
| minutes/use | 8.2 | Average shower duration per LBNL study.[7] |
| uses/person/day | 0.75 | LBNL showers per day per capita.[8] |
| person/ household | Single Family: 2.8 Multifamily: 2.0 | Persons per household [9,10] |
| $T_{main}$ | | 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[11] |
| UEF | See UEF Table Below | Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern)[12] |

[3] 2017 NYS Uniform Code Supplement, Table P2903.2
[4] 2014 NYC Plumbing Code, Table 604.4
[5] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[6] 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.
[7] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[8] Ibid.
[9] Residential Statewide Baseline Study of New York State, July 2015. Volume 1: Single-Family Report, Table 9
[10] Residential Statewide Baseline Study of New York State, July 2015. Volume 2: Multifamily Report, Table 8
[11] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014
[12] 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)

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.[13] Supply main temperatures based on the annual outdoor temperature are shown below.

| City | Annual average outdoor temperature[14] (°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.[15] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a 40-gallon rated storage volume, Medium draw storage type system with primary water heater fuel from application.

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

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

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

Residential Water Heaters

| Product Class | Rated Storage Volume and Input Rating | Draw Pattern | Uniform Energy Factor |
|---|---|---|---|
| Gas-Fired Storage Water Heater | ≥ 20 gal and ≤ 55 gal | Very Small | $0.3456 - (0.0020 \times V_t^*)$ |
| | | Low | $0.5982 - (0.0019 \times V_t)$ |
| | | Medium | $0.6483 - (0.0017 \times V_t)$ |
| | | High | $0.6920 - (0.0013 \times V_t)$ |
| | > 55 gal and ≤ 100 gal | Very Small | $0.6470 - (0.0006 \times V_t)$ |
| | | Low | $0.7689 - (0.0005 \times V_t)$ |
| | | Medium | $0.7897 - (0.0004 \times V_t)$ |
| | | High | $0.8072 - (0.0003 \times V_t)$ |
| Electric Storage Water Heater | ≥ 20 gal and ≤ 55 gal | Very Small | $0.8808 - (0.0008 \times V_t)$ |
| | | Low | $0.9254 - (0.0003 \times V_t)$ |
| | | Medium | $0.9307 - (0.0002 \times V_t)$ |
| | | High | $0.9349 - (0.0001 \times V_t)$ |
| | > 55 gal and ≤ 100 gal [16] | Very Small | $1.9236 - (0.0011 \times V_t)$ |
| | | Low | $2.0440 - (0.0011 \times V_t)$ |
| | | Medium | $2.1171 - (0.0011 \times V_t)$ |
| | | High | $2.2418 - (0.0011 \times V_t)$ |
| 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 |

First Hour Rating vs. Draw Pattern[17]

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

[16] Electric Storage Water Heaters > 55 gallons and ≤ 100 gallons are Heat Pump water heaters
[17] 10 CFR 429.17

### Compliance Efficiency from which Incentives are Calculated

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. [18]

### 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

N/A

### Ancillary Electric Savings Impacts

N/A

### References


1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from:
   http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Lawrence Berkeley National Laboratory (LBNL): "Potential Water and Energy Savings from Showerheads", March 2006
   Available from: http://www.map-testing.com/assets/files/Biermayer,%20P.%20(2006)%20Potential%20Water%20and%20Energy%20Savings%20from%20Showerheads.pdf


[18] Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory

4. United States Census Bureau, American Housing Survey – Table Creator, New York, 2017, Housing Unit Characteristics
   Available from: https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html#?s_areas=a00036&s_year=s2017&s_tableName=Table0&s_byGroup1=a1&s_byGroup2=a1&s_filterGroup1=t1&s_filterGroup2=g1&s_show=S
5. Residential Statewide Baseline Study of New York State, July 2015.
   Available From:
   https://www.nyserda.ny.gov/About/Publications/Building%20Stock%20and%20Potential%20Studies/Residential%20Statewide%20Baseline%20Study%20of%20New%20York%20State
6. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
7. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
8. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
   Available from:
   http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf
9. EPA WaterSense® Partnership Program
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**Record of Revision**

| Record of Revision Number | Issue Date |
|---|---|
| 0 | 10/15/2010 |
| 6-13-4 | 6/30/2013 |
| 6-15-1 | 6/15/2015 |
| 6-17-4 | 6/30/2017 |
| 3-19-7 | 3/29/2019 |
| 6-19-6 | 1/1/2021 |
| | |

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## *DOMESTIC HOT WATER – CONTROL*

### THERMOSTATIC SHOWER RESTRICTION VALVE

**Measure Description**

This measure covers the installation of thermostatic shower restriction valves, which are valves attached to a showerhead supply for reduction of domestic hot water flow and associated energy usage. The device restricts hot water flow through the showerhead by activating the trickle or stop flow mode when water reaches a predetermined set temperature, as designed by the manufacturer. Although this device activates trickle/stop flow at a set temperature, it does not restrict flow when the valve is manually opened, and therefore should not be considered a safety measure to prevent scalding.

**Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings**

*Annual Electric Energy Savings (Electric Water Heating Only)*

$$\Delta kWh = units \times (\Delta kWh/\text{unit})$$

*Summer Peak Coincident Demand Savings (Electric Water Heating Only)*

$$\Delta kW = Negligible$$

*Annual Gas Energy Savings (Gas Water Heating Only)*

$$\Delta therms = units \times (\Delta therms/\text{unit})$$

**where:**

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
(ΔkWh/unit) = Annual electric energy savings per unit
(Δtherms/unit)= Annual gas energy savings per unit

**Summary of Variables and Data Sources**

| Variable | Value | Notes |
|---|---|---|
| (ΔkWh/unit) | As defined in kWh Savings table below | Deemed annual electric energy savings for electric resistance storage tank water heater. Look up based on location and water usage rate (table below). |

| Variable | Value | Notes |
|---|---|---|
| (Δtherms/unit) | As defined in Therm Savings table below | Deemed annual gas energy savings for natural gas storage tank water heater. Look up based on location and water usage rate (table below). |

kWh Savings (ΔkWh/unit) – *Single Family*

| Location | Flow Rate (GPM) | | | | |
|---|---|---|---|---|---|
| | 1 | 1.25 | 1.5 | 1.75 | 2 |
| Albany | 64 | 80 | 96 | 112 | 128 |
| Binghamton | 66 | 83 | 100 | 116 | 133 |
| Buffalo | 64 | 80 | 96 | 112 | 128 |
| Massena | 70 | 88 | 105 | 123 | 140 |
| NYC | 55 | 68 | 82 | 96 | 110 |
| Poughkeepsie | 62 | 77 | 93 | 108 | 124 |
| Syracuse | 64 | 80 | 96 | 112 | 128 |

kWh Savings (ΔkWh/unit) – *Multifamily*

| Location | Flow Rate (GPM) | | | | |
|---|---|---|---|---|---|
| | 1 | 1.25 | 1.5 | 1.75 | 2 |
| Albany | 46 | 57 | 68 | 80 | 91 |
| Binghamton | 47 | 59 | 71 | 83 | 95 |
| Buffalo | 46 | 57 | 68 | 80 | 91 |
| Massena | 50 | 63 | 75 | 88 | 100 |
| NYC | 39 | 49 | 59 | 68 | 78 |
| Poughkeepsie | 44 | 55 | 66 | 77 | 89 |
| Syracuse | 46 | 57 | 68 | 80 | 91 |

The values in the kWh Savings table were calculated as follows, using the assumed values listed in the Summary of Variables and Data Sources table above:

$$(\Delta\text{kWh/unit}) = GPM \times Throttle_{fac} \times Waste\ Time \times \frac{1}{F_{shower}} \times \frac{Showers}{person/day} \times \frac{person}{household} \times 365\frac{days}{year} \times (T_{shower} - T_{main}) \times \frac{8.33}{3{,}412} \times \frac{1}{UEF_{elec}}$$

Therm Savings (Δtherm/unit) – *Single Family*

| Location | Flow Rate (GPM) | | | | |
|---|---|---|---|---|---|
| | 1 | 1.25 | 1.5 | 1.75 | 2 |
| Albany | 3.5 | 4.3 | 5.2 | 6.1 | 6.9 |
| Binghamton | 3.6 | 4.5 | 5.4 | 6.3 | 7.2 |
| Buffalo | 3.5 | 4.3 | 5.2 | 6.1 | 6.9 |
| Massena | 3.8 | 4.7 | 5.7 | 6.6 | 7.6 |
| NYC | 3.0 | 3.7 | 4.4 | 5.2 | 5.9 |
| Poughkeepsie | 3.4 | 4.2 | 5.0 | 5.9 | 6.7 |
| Syracuse | 3.5 | 4.3 | 5.2 | 6.1 | 6.9 |

Therm Savings (Δtherm/unit) – *Multifamily*

| Location | Flow Rate (GPM) | | | | |
|---|---|---|---|---|---|
| | 1 | 1.25 | 1.5 | 1.75 | 2 |
| Albany | 2.5 | 3.1 | 3.7 | 4.3 | 4.9 |
| Binghamton | 2.6 | 3.2 | 3.9 | 4.5 | 5.1 |
| Buffalo | 2.5 | 3.1 | 3.7 | 4.3 | 4.9 |
| Massena | 2.7 | 3.4 | 4.1 | 4.7 | 5.4 |
| NYC | 2.1 | 2.6 | 3.2 | 3.7 | 4.2 |
| Poughkeepsie | 2.4 | 3.0 | 3.6 | 4.2 | 4.8 |
| Syracuse | 2.5 | 3.1 | 3.7 | 4.3 | 4.9 |

The values in the Therm Savings table were calculated as follows, using the assumed values listed in the Summary of Variables and Data Sources table above:

$$(\Delta\text{therms/unit}) = GPM \times Throttle_{fac} \times Waste\ Time \times \frac{1}{F_{shower}} \times \frac{Showers}{person/day} \times \frac{person}{household} \times 365\frac{days}{year} \times (T_{shower} - T_{main}) \times \frac{8.33}{100{,}000} \times \frac{1}{UEF_{gas}}$$

**where:**

GPM = Gallon per minute
$Throttle_{fac}$ = Throttle factor
Waste Time = Time water runs before shower begins
$F_{shower}$ = Shower Factor
$T_{shower}$ = Temperature (°F) at showerhead
$T_{main}$ = Temperature (°F) of supply water from main
UEF = Uniform Energy Factor
8.33 = Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kW equals 3,412 BTU/h
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Summary of Per Unit Savings Variables and Data Sources

| Variable | Value | Notes |
|---|---|---|
| GPM | | Gallons per minute for energy efficient measure, from application |
| $Throttle_{fac}$ | 0.9 | Used in LBNL study to adjust for average percent of full capacity that the shower valve is opened when in use.[1] |
| Waste Time | 0.98 | Average value calculated from total water waste duration of 581 shower events (59 secs.)[2] |

[1] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[2] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014

| Variable | Value | Notes |
|---|---|---|
| $F_{shower}$ | 1.4 | Factor capturing average number of showers per household[3] |
| Showers/ person/day | 0.75 | LBNL study, showers per day per capita[4] |
| Person/ household | Single Family: 2.8<br>Multifamily: 2.0 | Persons per household [5,6] |
| $T_{main}$ | | Average inlet water temperature (°F) by location is shown below. |
| $T_{shower}$ | 104 | Average temperature at showerhead[7] |
| $UEF_{elec}$ | 0.92 | Uniform Energy Factor based on product class, size, input rating and draw pattern. Assumes electric storage water heater with 40-gal capacity at medium draw. [8] See Residential Water Heaters table below for calculating UEF for specific system types. |
| $UEF_{gas}$ | 0.58 | Uniform Energy Factor based on product class, size, input rating and draw pattern. Assumes natural gas storage water heater with 40-gal capacity at medium draw.[9] See Residential Water Heaters table below for calculating UEF for specific system types. |

Cold Water Inlet Temperature ($T_{main}$)

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

| City | Annual average outdoor temperature[11] (°F) | $T_{main}$ (°F) |
|---|---|---|
| Albany | 48.3 | 54.3 |
| Binghamton | 46.3 | 52.3 |

[3] United States Census Bureau, American Housing Survey – Table Creator, New York, 2017, Housing Unit Characteristics, All Housing Units. The shower factor reflects the average number of showers per household and was calculated by taking the average number of complete bathrooms per household, as follows: {[(number of homes with 1 bathroom)+(number of homes with 1.5 bathroom)]*1+[(number of homes with 2 bathrooms)+(number of homes with 2.5 bathrooms)]*2…etc} / (total number of homes). Per US Census data, average number of showers per home = {[4594+1199]*1+[1352+636.7]*2+[419.9]*3+[91.7]*4}/8293.3 = 1.37. Granularity at the single vs. multifamily level was not available.

[4] LBNL: Potential Water and Energy Savings from Showerheads, March 2006

[5] Residential Statewide Baseline Study of New York State, July 2015. Volume 1: Single-Family Report, Table 9

[6] Residential Statewide Baseline Study of New York State, July 2015. Volume 2: Multifamily Report, Table 8

[7] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014

[8] 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)

[9] Ibid.

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

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

| City | Annual average outdoor temperature[11] (°F) | $T_{main}$ (°F) |
|---|---|---|
| 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**

If known and in compliance with applicable code, the actual flowrate of the showerhead should be used for determination of per unit energy savings from the tables above. Otherwise, a baseline of 2.0 gallons per minute shall be used for compliance in New York State (per 2017 NYS Uniform Code Supplement) and New York City, (per 2014 update to NYC Plumbing Code). 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.[12] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a 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 | Uniform Energy Factor |
|---|---|---|---|
| Gas-Fired Storage Water Heater | ≥ 20 gal and ≤ 55 gal | Very Small | $0.3456 - (0.0020 \times V_t^*)$ |
| | | Low | $0.5982 - (0.0019 \times V_t)$ |
| | | Medium | $0.6483 - (0.0017 \times V_t)$ |
| | | High | $0.6920 - (0.0013 \times V_t)$ |
| | > 55 gal and ≤ 100 gal | Very Small | $0.6470 - (0.0006 \times V_t)$ |
| | | Low | $0.7689 - (0.0005 \times V_t)$ |
| | | Medium | $0.7897 - (0.0004 \times V_t)$ |
| | | High | $0.8072 - (0.0003 \times V_t)$ |

[12] 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 | Uniform Energy Factor |
|---|---|---|---|
| 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 $V_t$) |
| | > 55 gal and ≤ 100 gal [13] | 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 $V_t$) |
| 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[14]

| 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**

The compliance condition requires the installation of a thermostatic restriction valve on a residential shower.

**Operating Hours**

Estimate of energy savings assumes 2 showers per day with an average of 59 seconds of wasted hot water, reflecting the amount of time the shower is running but not in use.

**Effective Useful Life (EUL)**

See Appendix P.

**Ancillary Fossil Fuel Savings Impacts**

N/A

[13] Electric Storage Water Heaters > 55 gallons and ≤ 100 gallons are heat pump water heaters
[14] 10 CFR 429.17

**Ancillary Electric Savings Impacts**

N/A

**References**


1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
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9. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
10. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
    Available from:
    http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf
11. Uniform Plumbing Code (UPC) certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a.
12. 10 CFR 429.17 Water heaters.
    Available from: : https://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=10:3.0.1.4.17#se10.3.429_117
13. AHRI Directory of Certified Product Performance
    Available from: https://www.ahridirectory.org/ahridirectory/pages/home.aspx

**Record of Revision**

| Record of Revision Number | Issue Date |
|---|---|
| 6-14-2 | 6/19/2014 |
| 6-17-3 | 6/30/2017 |
| 3-19-6 | 3/29/2019 |
| 6-19-7 | 1/1/2021 |
| | |

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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[1] 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.[2]

**Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings**

*Annual Electric Energy Savings*

$$\Delta kWh = N/A$$

*Summer Peak Coincident Demand Savings*

$$\Delta kW = N/A$$

*Annual Gas Energy Savings*

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

**where:**

| | |
|---|---|
| ΔkWh | = Annual electric energy savings |
| ΔkW | = Peak coincident demand electric savings |
| Δtherms | = Annual gas energy savings |
| units | = Number of TRV's installed |
| (Δtherms/HDD) | = Annual gas energy savings per Heating Degree Day (HDD), per TRV |

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

[2] 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 |
|---|---|---|
| ΔTherms/HDD | 0.004318 | Average gas savings per HDD per unit[3] |
| $HDD_{loc}$ | | 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.[4]

| 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.

[3] 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.
[4] 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

N/A

### Ancillary Electric Savings Impacts

N/A

### References


1. NYSERDA, Thermostatic Radiator Valve (TRV) Demonstration Project, Report No. 95-14, September 1995
   Available from:
   https://digital.library.unt.edu/ark:/67531/metadc620708/m2/1/high_res_d/119941.pdf
2. US DOE, Thermostatic Radiator Valve Evaluation, January 2015
   Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf
3. 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.
   Available from: https://www.osti.gov/servlets/purl/119941
4. NYS Plumbing Code 2016, per 2015 International Plumbing Code, Appendix D – Degree Day and Design Temperatures Table D-101
   Available from: https://codes.iccsafe.org/public/document/IPC2015NY/appendix-d-degree-day-and-design-temperatures
5. NOAA National Centers for Environmental Information – NCEI 1981-2010 Normals
   Available from: http://www.ncdc.noaa.gov/cdo-web/datatools/normals


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| 1-16-12 | 12/31/2015 |
| 6-17-7 | 6/30/2017 |
| 6-19-8 | 1/1/2021 |
| | |

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## *COMPRESSED AIR*

### AIR COMPRESSOR

**Measure Description**

This measure covers the installation of oil-flooded, rotary screw air compressors with variable frequency drives or variable displacement controls and properly sized air receivers in commercial and industrial compressed air systems (single compressor systems only). Inlet valve modulation, which modulates the compressor by throttling the air inlet and load/unload control, which switches the compressor to unload when the cut-out pressure set point is reached, are inefficient means of compressed air system control under part load conditions. Variable frequency drives modulate the frequency and speed of the compressor motor, which reduces input power. Variable displacement controls change the compressor capacity by varying the amount of the compressor used to compress air. Both represent a significant improvement in part load operating efficiency and savings over the baseline condition.[1]

**Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings**

*Annual Electric Energy Savings*

$$\Delta kWh = units \times hp_{comp} \times (\Delta kW/hp) \times hrs$$

*Summer Peak Coincident Demand Savings*

$$\Delta kW = units \times hp_{comp} \times (\Delta kW/hp) \times CF$$

*Annual Gas Energy Savings*

$$\Delta therms = N/A$$

**where:**

| | |
|---|---|
| ΔkWh | = Annual electric energy savings |
| ΔkW | = Peak coincident demand electric savings |
| Δtherms | = Annual gas energy savings |
| units | = Number of measures installed under the program |
| $hp_{comp}$ | = Horsepower of air compressor |
| (ΔkW/hp) | = Demand electric savings per horsepower |
| hrs | = Annual operating hours of air compressor |
| CF | = Coincidence factor |

[1] The Impact Evaluation of Custom Compressed Air, conducted by DNV GL for Niagara Mohawk Power Corporation d/b/a National Grid (approved March 2017), was reviewed for findings relevant to this measure. The findings of this report, which quantifies kWh and peak summer kW savings and associated realization rates for custom compressed air measures at 25 unique sites, do not directly inform the algorithms, key inputs or default values found in this energy savings estimation methodology. As such, no changes have been applied as a result of this review.

**Summary of Variables and Data Sources**

| Variable | Value | Notes |
|---|---|---|
| $hp_{comp}$ | | From application |
| (ΔkW/hp) | | Lookup in table below based on compressor size and control strategy.[2] |
| hrs | | From application |
| CF | 0.8 | |

Air Compressor Savings (ΔkW/hp)

| Control Type | Compressor hp | ΔkW/hp |
|---|---|---|
| Variable Frequency Drive | ≥ 15 and < 75 | 0.189 |
| Variable Frequency Drive | ≥ 75 | 0.216 |
| Variable Displacement | ≥ 50 and < 75 | 0.125 |
| Variable Displacement | ≥ 75 | 0.141 |

**Coincidence Factor (CF)**

The prescribed value for the coincidence factor is 0.8.[3]

**Baseline Efficiencies from which Energy Savings are Calculated**

The baseline condition is an oil-flooded, rotary screw compressor utilized in a single compressor system meeting the requirements of ISO Standard 8573.1 with load/unload control and blow down capability.

**Compliance Efficiency from which Incentives are Calculated**

The compliance condition is an oil-flooded, rotary screw compressor utilized in a single compressor system meeting the requirements of ISO Standard 8573.1 with variable speed drive or variable displacement capacity control and a properly sized air receiver. Flow controller must be used to maintain 5-10 psi pressure difference between receiver and distribution system.

**Operating Hours**

The operating hours of compressed air systems vary widely and shall be defined by the application.

[2] For equipment with < 75 hp: Energy saving factors from Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV-GL, prepared by KEMA, Inc. for Massachusetts Energy Efficiency Advisory Council, October 2015
For equipment with ≥ 75 hp: Energy savings factors were developed by using U.S. Dept. of Energy part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors. This data suggests an average 17% load reduction compared to baseline for Variable Displacement and an average 26% load reduction compared to baseline for Variable Frequency Drives and an average 90% operating efficiency for new compressor equipment. ΔkW/hp values were derived using these assumptions in the form: % Savings x 0.746\System Efficiency.

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

**Effective Useful Life (EUL)**

See Appendix P.

**Ancillary Fossil Fuel Savings Impacts**

N/A

**Ancillary Electric Savings Impacts**

N/A

**References**


1. "Improving Compressed Air System Performance": A sourcebook for Industry, U.S. Dept. of Energy, November 2003.
   Available from:
   https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/compressed_air_sourcebook.pdf
2. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV-GL, prepared by KEMA, Inc. for Massachusetts Energy Efficiency Advisory Council, October 2015
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf
3. Impact Evaluation of Custom Compressed Air, DNV GL, March 2017
   Available from:
   http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BE21FC3D0-70BC-426E-B35B-85E082640361%7D


**Record of Revisions**

| Record of Revision Number | Issue Date |
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| 1 | 10/15/2010 |
| 12-17-9 | 12/31/2017 |
| 3-19-9 | 3/29/2019 |
| 6-19-9 | 1/1/2021 |
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## *LIGHTING – CONTROL*

### INTERIOR LIGHTING CONTROL

**Measure Description**

This measure covers the installation of lighting control systems on lighting in interior spaces. Interior spaces are defined as any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. Lighting control systems covered under this measure include occupancy sensors, stepped and dimming daylighting controls and networked lighting control systems. These systems save energy and peak demand by shutting off power to lighting fixtures when the space is unoccupied or illumination is not required. They also save energy and demand by reducing power to lighting systems to correct for over-illumination due to excessive lamp output or the presence of daylight. This measure is not applicable in spaces for which occupancy or daylight-responsive controls are required by federal, state, local or municipal codes or standards. Refer to chapter C405.2 Lighting Controls (Mandatory) of the Energy Conservation Construction Code of New York State[1] (ECCCNYS) and the New York City Energy Conservation Code[2] (NYCECC) for details. Bi-level lighting controls installed in stairwells, corridors, parking garages and parking lots shall use the Commercial Bi-Level Lighting measure detailed in this TRM document.

**Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings**

*Annual Electric Energy Savings*

$$\Delta kWh = \left(\frac{W_{ctrl}}{1{,}000}\right) \times hrs_{baseline} \times ESF \times (1 + HVAC_c)$$

*Summer Peak Coincident Demand Savings*

$$\Delta kW = \left(\frac{W_{ctrl}}{1{,}000}\right) \times ESF \times (1 + HVAC_d) \times CF$$

*Annual Gas Energy Savings*

$$\Delta therms = \left(\frac{W_{ctrl}}{1{,}000}\right) \times hrs_{baseline} \times ESF \times HVAC_g$$

**where:**

| | |
|---|---|
| ΔkWh | = Annual electricity energy savings |
| ΔkW | = Peak coincident demand electric savings |
| Δtherms | = Annual gas energy savings |
| $W_{ctrl}$ | = Total wattage of controlled lighting (Watts) |
| 1,000 | = Conversion factor, one kW equals 1,000 Watts |
| hrs | = Lighting operating hours |

[1] ECCCNYS 2016; C405.2: Lighting Controls (Mandatory)
[2] NYCECC 2016; C405.2: Lighting Controls (Mandatory)

$_{baseline}$ = Baseline condition or measure
$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor for peak demand at NYISO coincident summer peak hour
$HVAC_g$ = HVAC interaction factor for annual natural gas consumption (therms/kWh)
ESF = Energy savings factor
CF = Coincidence factor

**Summary of Variables and Data Sources**

| Variable | Value | Notes |
|---|---|---|
| $W_{ctrl}$ | | Connected load of controlled lighting fixtures (in Watts), from application |
| $hrs_{baseline}$ | | Lighting operating hours. From application or see Operating Hours section below. |
| $HVAC_c$ | | HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D. For lighting in unconditioned space, use a value of 0. |
| $HVAC_d$ | | HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D. For lighting in unconditioned space, use a value of 0. |
| $HVAC_g$ | | HVAC interaction factor for annual natural gas energy consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D. For lighting in unconditioned space, use a value of 0. |
| ESF | | See Energy Savings Factors table below |
| CF | 1.0 | "Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. |

Energy Savings Factor[3]

The ***energy savings factor*** (ESF) is the average annual reduction in electric consumption achieved by a particular control measure type. Energy savings factors for various automated lighting control types are specified in the table below.

| Control Type | ESF |
|---|---|
| Occupant Sensing Controls in large open plan offices: one sensor controlling an area no larger than 125 square feet[4] | 0.40 |

[3] The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures; Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, National Renewable Energy Laboratory, September 2017, p. 15
[4] 2016 Title 24, part 6, Table 140.6-A: Lighting Power Adjustment Factors (PAF)

| Control Type | ESF |
|---|---|
| Occupant Sensing Controls in large open plan offices: one sensor controlling an area between 126 to 250 square feet[5] | 0.30 |
| Occupant Sensing Controls in large open plan offices: one sensor controlling an area between 251 to 500 square feet[6] | 0.20 |
| Occupant Sensing Controls: applicable to all space types other than large open plan offices with one sensor controlling an area less than 500 square feet | 0.20 |
| Institutional Tuning in non-daylit areas[7] | 0.10 |
| Institutional Tuning in daylit areas[8] | 0.05 |
| Demand Responsive Control in buildings 10,000 square feet or less[9] | 0.05 |
| Daylight Dimming Control – On/Off Control: Luminaries in skylit daylit zone or primary sidelit daylit zone[10] | 0.10 |
| Daylight Dimming Control – multiple step dimming[11] | 0.20 |
| Daylight Dimming Control – continuous dimming[12] | 0.30 |
| Occupant Sensing with Daylight Dimming Controls – On/Off controls[13] | 0.35 |
| Occupant Sensing with Daylight Dimming Controls – multiple step dimming[14] | 0.35 |
| Networked Lighting Controls[15] | 0.40 |
| Networked Lighting Controls: High Occupancy Hours (See Operating Hours section below)[16] | 0.47 |

- ***Occupancy Sensor*** – Reduces lighting operating hours by switching off lighting in unoccupied spaces.
- ***Institutional Tuning*** – Allows luminaries in layouts designed with the consideration of a light loss factor to be dimmed to the recommended light level and restored to full output when lumen output has degraded. Maximum light level adjustments are available only to authorized personnel.[17]
- ***Demand Responsive Control*** – Automatically reduces lighting in response to a demand response signal
- ***Daylight Dimming Control*** – Reduces lighting output to a set level in response to natural daylighting using continuous or stepped dimming capability.

[5] Ibid
[6] Ibid
[7] Ibid
[8] Ibid
[9] Ibid
[10] Ibid
[11] NREL, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, Table 4: Lighting Control Savings Factors by Control Type
[12] Ibid
[13] Ibid
[14] Ibid

[16] Energy Savings from Networked Lighting Control (NLC) Systems, DesignLights Consortium®, September 2017, pg 7.
[17] 2016 Title 24, part 6, page 64

- ***Networked Lighting Control*** – A networked lighting control system consists of an intelligent network of individually addressable luminaires and control devices, allowing for application of multiple control strategies, programmability, building- or enterprise-level control, zoning and rezoning using software, and measuring and monitoring, compliant with DesignLights Consortium V3.0 requirements.[18]

### Coincidence Factor (CF)

The prescribed coincidence factor for commercial indoor lighting measures is 1.0. [19]

### Baseline Efficiencies from which Energy Savings are Calculated

The baseline case for this measure is a lighting system with manual or time-switch controls.

### Compliance Efficiency from which Incentives are Calculated

The compliance case is a lighting system with occupancy and/or daylight-responsive controls designed and installed in accordance with manufacturers' and/or designer recommendations.

### Operating Hours

The baseline lighting operating hours are the average operating hours for all fixtures subject to lighting control measures before the lighting controls are installed. This information shall be taken from the application. If unavailable, refer to the "Operating Hours" section of the Commercial and Industrial Interior and Exterior Lighting measure for default hours of operation.

Networked Lighting Controls in facilities with occupancy hours that meet or exceed the hours outlined in the table below qualify as high occupancy hour facilities and achieve greater savings.[20]

| Facility Type | Occupancy Hours |
|---|---|
| Assembly | ≥ 5,000 |
| School | ≥ 5,000 |
| Manufacturing | ≥ 4,000 |
| Retail | ≥ 7,000 |
| Restaurant | ≥ 6,000 |
| Office | ≥ 4,500 |
| Warehouse | ≥ 6,000 |

### Effective Useful Life (EUL)

See Appendix P.

[18] Networked Lighting Controls V3.0 Requirements, DesignLights Consortium®

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

[20] Energy Savings from Networked Lighting Control (NLC) Systems, DesignLights Consortium®, September 2017, Figure 2. Only the building types listed are eligible for high occupancy designation.

### Ancillary Fossil Fuel Savings Impacts

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

### References


1. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures; Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, National Renewable Energy Laboratory, September 2017
   Available from: https://www.nrel.gov/docs/fy17osti/68559.pdf
2. Title 24: part 6; 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, California Energy Commission,
3. Networked Lighting Controls V3.0 Requirements, DesignLights Consortium®
   Available from: https://www.designlights.org/workplan/networked-lighting-controls-specification/
4. Energy Savings from Networked Lighting Control (NLC) Systems, DesignLights Consortium®, September 21, 2017
   Available from: https://www.designlights.org/lighting-controls/reports-tools-resources/nlc-energy-savings-report/
5. ECCCNYS 2016, per IECC 2015; Chapter C405.2: Lighting Controls (Mandatory)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
6. NYCECC 2016: Chapter C405.2: Lighting Controls (Mandatory)
   Available from: https://www1.nyc.gov/site/buildings/codes/2016-energy-conservation-code.page


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| 9-17-7 | 9/30/2017 |
| 3-19-10 | 3/29/2019 |
| 6-19-11 | 1/1/2021 |
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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[1] |
| | Clothes Dryer | Residential | 14 | ENERGY STAR® M&I Scoping Report[2] |
| | Clothes Washer | Residential | 11 | DEER 2014 EUL ID: Appl-EffCW |
| | Dehumidifier | Residential | 12 | ENERGY STAR® Calc[3] |
| | Dishwasher | Residential | 11 | DEER 2014 EUL ID: Appl-EffDW |
| | Refrigerator and Freezer | Residential | 14 | DEER 2014 EUL ID: Appl-ESRefg |
| | Soundbar | Residential | 7 | RPP Product Analysis[4] |
| **Appliance Control** | Advanced Power Strip (APS) | Residential | 8 | DEER 2014 EUL ID: Plug-OccSens |
| **Appliance Recycling** | Air Conditioner - Room (RAC) Recycling | Residential | 3 | DEER 2014 EUL ID: HV-RAC-RUL |
| | Refrigerator Recycling | Residential | 5 | DEER 2014 EUL ID: Appl-RecRef |
| | Freezer Recycling | Residential | 4 | DEER 2014 EUL ID: Appl-RecFrzr |
| **Building Shell** | Air Conditioner – Room (RAC) Cover and Gap Sealer | Residential | 5 | See note below[5] |
| | Air Leakage Sealing | Residential | 15 | GDS[6] |

[1] 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
[2] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[3] ENERGY STAR® Dehumidifier Calculator
https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[4] Retail Products Platform Product Analysis, Last Updated May 25, 2016.
Available from: https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view
[5] At least one manufacturer's warranty period. www.gss-ee.com/products.html
[6] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures

| Category | Single and Multi-family Residential Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Building Shell** | Insulation – Hot Water and Steam Pipe | Residential | 15 | GDS[7] |
| | Insulation – Opaque Shell | Residential | 25 | GDS[8] |
| | Window | Residential | 20 | DEER 2014 EUL ID: BS-Win |
| **Domestic Hot Water** | Heat Pump Water Heater (HPWH) | Residential | 10 | DEER 2014 EUL ID: WtrHt-HtPmp |
| | Indirect Water Heater | Residential | 11 | DEER 2014 EUL ID: WtrHt-Res-Gas |
| | Storage Water Heater - Gas | Residential | 15 | PA Consulting Group[9] |
| | Storage Water Heater - Electric | Residential | 13 | DEER 2014 EUL ID: WtrHt-Res-Elec |
| | Instantaneous Water Heater | Residential | 20 | DEER 2014 EUL ID: WtrHt-Instant-Res |
| **Domestic Hot Water - Control** | Drain Water Heat Recovery | Residential | 30 | 2019 Title 24[10] |
| | 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[11] |
| **Heating, Ventilation and Air Conditioning (HVAC)** | Air Conditioner – Central (CAC) | Residential | 15 | DEER 2014 EUL ID: HV-ResAC |
| | Air Conditioner – Room (RAC) | Residential | 12 | GDS[12] |
| | 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 |

[7] Ibid.
[8] Ibid.
[9] 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
[10] 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
[11] 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.
[12] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures

| Category | Single and Multi-family Residential Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| Heating, Ventilation and Air Conditioning (HVAC) | Boiler, 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[13] |
| | Boiler and Furnace - Combination ("Combi") Furnace | Residential | 20 | DEER[14] |
| | Duct Sealing and Insulation | Residential | 18 | DEER 2014 EUL ID: HV-DuctSeal |
| | Electronically Commutated (EC) Motor – HVAC Blower Fan | Residential | 15 | DEER 2014 EUL ID: Motors-fan |
| | Electronically Commutated (EC) Motor – Hydronic Circulator Pump | Residential | 15 | DEER 2014 EUL ID: Motors-pump |
| | Furnace, Gas Fired | Residential | 22 | DOE[15,16] |
| | Heat Pump - Air Source (ASHP) | Residential | 15 | DEER 2014 EUL ID: HV-Res HP |
| | Heat Pump – Ground Source (GSHP) | Residential | 25 | ASHRAE[17] |
| | 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 |

[13] 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
[14] Based on DEER value for high efficiency boiler and instantaneous water heater
[15] 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
[16] 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
[17] 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** | Outdoor Temperature Setback Control for Hydronic Boiler | Residential | EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.) | N/A |
| | Steam Trap – Low Pressure Space Heating | Residential | 6 | DEER 2014 EUL ID: HVAC-StmTrp |
| | Submetering | Multifamily | 10 | NYSERDA[18] |
| | Thermostat – Programmable Setback<br>Thermostat – Wi-Fi (Communicating)<br>Thermostat – Learning | Residential | 11 | DEER 2014 EUL ID: HVAC-ProgTStats |
| | Thermostatic Radiator Valve – One Pipe Steam Radiator | Multifamily | 15 | DOE[19] |

[18] NYSERDA Residential Electric Submetering Manual
[19] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. Cost-Benefit Financial Assumptions, pg. 16

| Category | Single and Multi-family Residential Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Lighting** | Compact Fluorescent Lamp (CFL) | Residential | Coupon – 5 | GDS |
| | | | Direct Inst. – 7 | GDS |
| | | | Markdown - 7 | GDS |
| | | Multifamily Common Area | 9,000 hrs/ annual lighting operating hrs | See note below[20] |
| | LED Lamp (Directional) | Residential/ Multifamily Common Area | 25,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less) | ENERGY STAR® Lamps[21] |
| | | | 35,000 or 50,000 hours | DLC[22] |
| | LED Lamp (Decorative & Omnidirectional) | Residential/ Multifamily Common Area | 15,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less) | ENERGY STAR® Lamps |

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

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

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

| Category | Single and Multi-family Residential Measures | | Sector | EUL (years) | Source |
|---|---|---|---|---|---|
| **Lighting** | Light Fixture | LED (Interior) | Residential/ Multifamily | 25,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less) | ENERGY STAR® Fixtures[23] |
| | | LED (Exterior) | Residential/ Multifamily Common Area | 35,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less) | ENERGY STAR® Fixtures |
| | | Linear Fluorescent | Residential/ Multifamily Common Area | 70,000 hrs / annual lighting operating hrs, or 15 yrs (whichever is less) | DEER 2014[24] EUL ID: ILtg-Lfluor-CommArea |
| | | CFL | Residential/ Multifamily Common Area | 22,000 hrs / annual lighting operating hrs, or 20 yrs (whichever is less) | See note below[25] |
| **Lighting Control** | Bi-Level Lighting | | Multifamily Common Area | 15 | ComEd[26] |
| **Motors and Drives** | Pool Pump | | Residential | 10 | DEER 2014 EUL ID: OutD-PoolPump |
| **Other** | Pool Heater | | Residential | 8 | DOE[27] |

[23] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.0, May 2015, p. 17 (Capped at 20 years).
https://www.energystar.gov/sites/default/files/Luminaires%20V2%200%20Final.pdf
[24] Basis value 70,000 hours, capped at 20 years, is common given redecoration patterns
[25] Basis value 22,000 hour ballast life per US EPA. Capped at 20 years as above (2.5 hours per day average lamp operation)
[26] 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
[27] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75 Available from:
https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170

## COMMERCIAL AND INDUSTRIAL MEASURES

| Category | Commercial & Industrial Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Agricultural Equipment - Control** | Engine Block Heater Timer | C&I | 8 | See note below[28] |
| **Appliance** | Clothes Dryer | C&I | 14 | ENERGY STAR®M&I Report[29] |
| | Cooking Equipment | C&I | 12 | DEER 2014 EUL IDs: Various |
| | Dishwasher | C&I | 10 – Under Counter<br>15 – Single Door<br>20 – Conveyor Type<br>10 – Pots, Pans & Utensils | ENERGY STAR®Calc[30] |
| | Ice Maker | C&I | 10 | DEER 2014 EUL ID: Cook-IceMach |
| | Refrigerator and Freezer | C&I | 12 | DEER 2014 EUL ID: Cook-SDRef |
| **Appliance - Control** | Advanced Power Strip (APS) | C&I | 8 | DEER 2014 EUL ID: Plug-OccSens |
| | Vending Machine and Novelty Cooler Control | C&I | 5 | DEER 2014 EUL ID: Plug-VendCtrler |
| **Appliance Recycling** | Air Conditioner – Room (RAC) | C&I | 9 | DEER 2014 EUL ID: HV-RAC-ES |
| **Building Shell** | Cool Roof | C&I | 15 | DEER 2014 EUL ID: BldgEnv-CoolRoof |
| | Insulation - Hot Water and Steam Pipe | C&I | 15 | GDS[31] |
| | Insulation - Opaque Shell | C&I | 30 | ET & CEC[32] |
| | Window - Film | C&I | 10 | DEER 2014 EUL ID: GlazDaylt-WinFilm |
| | Window - Glazing | C&I | 20 | DEER 2014 EUL ID: BS-Win |
| **Compressed Air** | Air Compressor | C&I | 13 | Other State TRMs[33] |
| | Engineered Air Nozzle | C&I | 15 | Wisconsin PSC[34] |

[28] Based on EUL's for similar control technology
[29] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[30] 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
[31] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[32] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[33] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (March 2015). Estimates range from 10 to 15 years.
[34] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission

| Category | Commercial & Industrial Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Compressed Air** | No Air Loss Water Drain | C&I | 13 | MA Measure Life Study C&I Retrofit EUL[35] |
| | Refrigerated Air Dryer | C&I | 13 | Other State TRMs [36] |
| **Domestic Hot Water (DHW)** | Domestic Hot Water Tank Blanket | C&I | 7 | DEER |
| | Heat Pump Water Heater (HPWH) | C&I | 10 | DEER |
| | Indirect Water Heater | C&I | 15 | DEER 2014 EUL ID: WtrHt-Com |
| | Instantaneous Water Heater | C&I | 20 | DEER 2014 EUL ID: WtrHt-Instant-Com |
| | Storage Tank Water Heater | C&I | 15 | DEER 2014 EUL ID: WtrHt-Com |
| **DHW - Control** | Low-Flow – Faucet Aerator | C&I | 10 | DEER 2014 EUL ID: WtrHt-WH-Aertr |
| | Low-Flow – Pre-Rinse Spray Valve (PRSV) | C&I | 5 | GDS |
| | Low-Flow – Salon Valve | C&I | 10 | DEER 2014 EUL ID: WtrHt-WH-Shrhd |
| | Low-Flow – Showerhead | C&I | 10 | DEER 2014 EUL ID: WtrHt-WH-Shrhd |
| **Heating, Ventilation and Air Conditioning (HVAC)** | Air Conditioner – PTAC | C&I | 15 | DEER 2014 EUL ID: HVAC-PTAC |
| | Air Conditioner – Unitary | C&I | 15 | DEER 2014 EUL ID: HVAC-airAC |
| | Boiler and Furnace - Combination (“Combi”) Boiler | C&I | 22 | DOE[37] |
| | Boiler and Furnace - Combination (“Combi”) Furnace | C&I | 20 | DEER[38] |
| | 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 |

[35] 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

[36] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (March 2015). Estimates range from 10 to 15 years.

[37] 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

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

| Category | Commercial & Industrial Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Heating, Ventilation and Air Conditioning (HVAC)** | Chiller – Cooling Tower | C&I | 15 | DEER 2014 EUL ID: HVAC-ClTwrPkgSys |
| | Condensing Unit Heater | C&I | 18 | Ecotope[39] |
| | 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 |
| | Economizer –Dual Enthalpy Air Side | C&I | 10 | DEER 2014 EUL ID: HVAC-addEcono |
| | Furnace, Gas Fired | C&I | 23 | DOE[40],[41] |
| | 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[42] |
| | Infrared Heater | C&I | 17 | GDS[43] |
| | 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[44] |
| | Variable Refrigerant Flow (VRF) System | C&I | 15 | DEER 2014 EUL ID: HVAC-VSD-pump |
| | Unit Heater, Gas Fired | C&I | 13 | ASHRAE Handbook, 2015 |
| **HVAC - Control** | Direct Digital Control (DDC) System | C&I | 15 | DEER 2014 EUL ID: HVAC-EMS |
| | Demand Controlled Ventilation (DCV) | C&I | 15 | DEER 2014 EUL ID: HVAC-VSD-DCV |
| | Energy Management System | C&I | 15 | DEER 2014 EUL ID: HVAC-EMS |

[39] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)
[40] 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
[41] 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
[42] ASHRAE Owning and Operating Cost Database
Available from: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[43] 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
[44] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

| Category | Commercial & Industrial Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **HVAC – Control** | Energy Management System – Guest Room | C&I | 15 | DEER 2014<br>EUL ID: HVAC-EMS |
| | Outdoor Temperature Setback Control for Hydronic Boiler | C&I | EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.) | N/A |
| | Steam Trap – Low-Pressure Space Heating | C&I | 6 | DEER 2014<br>EUL ID: HVAC-StmTrp |
| | Thermostat – Programmable Thermostat – Wi-Fi (Communicating) | C&I | 11 | DEER 2014<br>EUL ID: HVAC-ProgTStats |
| | Thermostatic Radiator Valve | C&I | 15 | DOE[45] |
| **Lighting** | CFL Lamp | C&I | 9,000 hours /annual lighting operating hours | See note below[46] |
| | CFL Light Fixture | C&I | 12 | DEER 2014<br>EUL ID: ILtg-CFLfix-Com |
| | HID | C&I | 70,000 hours /annual lighting operating hours or 15 years (whichever is less) | DEER 2014<br>EUL ID: ILtg-HPS |
| | Linear Fluorescent | C&I | 70,000 hours /annual lighting operating hours or 15 years, (whichever is less) | DEER 2014[47]<br>EUL ID: ILtg-Lfluor-Elec |

[45] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf

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

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

| Category | Commercial & Industrial Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Lighting** | LED Fixture (other than refrigerated case) | C&I | 50,000 hours /annual lighting operating hours or 20 years (whichever is less) | DLC[48] |
| | | | 35,000 hours /annual lighting operating hours or 20 years (whichever is less) | ENERGY STAR®[49] |
| | | | 25,000 hours /annual lighting operating hours or 20 years (whichever is less) | Uncertified |
| | LED Screw-In Lamp | C&I | 15,000 hours (decorative) or 25,000 hours (all other)/ annual lighting operating hours or 20 years (whichever is less) | ENERGY STAR® |
| | Refrigerated Case LED | C&I | 16 | DEER 2014 EUL ID: GrocDisp-FixtLtg-LED |
| **Lighting - Control** | Bi-Level Lighting | C&I | 15 | ComEd[50] |
| | Integrated Interior Lighting Control | C&I | 15 | ComEd[51] |
| | Non-Integrated Interior Lighting Control | C&I | 10 | GDS[52] |
| | Plug-Load Occupancy Sensor | C&I | 8 | DEER[53] |

[48] 50,000 hours per $L_{70}$ requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.2

[49] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.0. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns

[50] 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

[51] 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

[52] 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

[53] DEER value for lighting occupancy sensors

| Category | Commercial & Industrial Measures | Sector | EUL (years) | Source |
|---|---|---|---|---|
| **Motors and Drives** | Motor | C&I | 15 | DEER 2014 EUL ID: Motors-HiEff |
| | Variable Frequency Drive (VFD) – Fan and Pump | C&I | 15 | DEER 2014 EUL ID: HVAC-VSDSupFan |
| **Other** | Pool Heater | C&I | 8 | DOE[54] |
| **Process Equipment** | Steam Trap – Other Applications | C&I | 6 | DEER 2014 EUL ID: HVAC-StmTrp |
| **Refrigeration** | Air-Cooled Refrigeration Condenser | C&I | 15 | DEER 2014 EUL ID: GrocSys-Cndsr |
| | Automatic Door Closer for Walk-In Cooler/Freezer | C&I | 8 | DEER |
| | Cooler and Freezer Door Gasket | C&I | 4 | DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask |
| | Cooler and Freezer Door Strip | C&I | 4 | DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask |
| | Electronically Commutated (EC) Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan | C&I | 15 | DEER 2014 EUL ID: GrocDisp-FEvapFanMtr |
| | Equipment (Condenser, Compressor, and Sub-cooling) | C&I | 15 | DEER |
| | Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM) | C&I | 15 | DEER 2014 EUL ID: GrocDisp-FEvapFanMtr |
| | Refrigerated Case Door | C&I | 12 | DEER 2014 EUL ID: GrocDisp-FixtDoors |
| | Refrigerated Case Night Cover | C&I | 5 | DEER 2014 EUL ID: GrocDisp-DispCvrs |
| **Refrigeration - Control** | Anti-Condensation Heater Control | C&I | 12 | DEER 2014 EUL ID: GrocDisp-ASH |
| | Condenser Pressure and Temperature Control | C&I | 15 | DEER |
| | Evaporator Fan Control | C&I | 16 | DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl |

[54] 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

**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 | 6/28/2019 |
| | |

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# GLOSSARY

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

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

| | |
|---|---|
| Ecotope | Ecotope Consulting, Redlands, CA |
| ee | Energy efficient condition or measure |
| EEPS | Energy Efficiency Portfolio Standard |
| EER | Energy efficiency ratio under peak conditions |
| EF | Energy factor |
| Eff | Efficiency |
| $E_c$ | Combustion efficiency |
| Efficiency Vermont | State of Vermont Energy and Efficiency Initiatives |
| $E_t$ | Thermal efficiency |
| EFLH | Equivalent full-load hours |
| EIA | Energy Information Administration, US |
| EISA | Energy Independence and Security Act (EISA) of 2007 |
| ElecSF | Electric Savings Factor |
| ENERGY STAR® | U.S. Environmental Protection Agency voluntary program |
| Energy Trust | Energy Trust of Oregon, Inc. |
| EPA | Environmental Protection Agency (EPA), US |
| EPACT | Energy Policy and Conservation Act of 2005 |
| EPDM | Ethylene propylene diene monomer roofing membrane |
| ERV | Energy recovery ventilation |
| ESF | Energy savings factor |
| EUL | Effective useful life |
| EFan | Evaporator fan |
| Exh | Exhaust |
| F | Factor |
| $F_{derate}$ | Aggregate derating factor |
| $F_{elec}$ | Percentage of energy consumed that is derived from electricity |
| $F_{gas}$ | Percentage of energy consumed that is derived from gas |
| $F_h$ | Zone correction for blower door infiltration rate to natural air changes |
| $F_n$ | Height correction for blower door infiltration rate to natural air changes |
| $F_{peak}$ | Peak operation factor |
| FEMP | Federal Energy Management Program |
| FL | Full-load chiller efficiency under peak conditions |
| FLH | Full-load hours |
| Flow | Nozzle flow |
| FPFC | Four pipe fan coil |
| ft | Foot |
| $ft^2$ | Square feet |
| $ft^3$ | Cubic feet |
| GasSF | Gas Savings Factor |
| GDS | GDS Associates, Marietta, GA |
| Glazing area | Aperture area of glazing |
| GPD | Gallons Per Day |

| | |
|---|---|
| GPM | Gallons Per Minute |
| GSHP | Ground source heat pump |
| $\Delta H_{vap}$ | Heat of vaporization (latent heat), in BTU/lb |
| $H_2O_{savings}$ | Water savings |
| HDD | Heating degree days - The number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application. |
| HID | High intensity discharge lamp |
| hp | Horsepower |
| $hp_{max}$ | Maximum motor horsepower |
| $hp_{peak}$ | Horsepower at which motor achieves peak efficiency |
| HP | High performance |
| hrs | Hours |
| $hrs_{operating}$ | Operating hours |
| HSPF | Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt-hour) |
| ht | Height |
| HVAC | Heating, ventilation, and air conditioning |
| $HVAC_c$ | HVAC interaction factor for annual electric energy consumption |
| $HVAC_d$ | HVAC interaction factor at utility summer peak hour |
| $HVAC_g$ | HVAC interaction factor for annual natural gas consumption |
| HW | Hot water |
| IECC | International Energy Conservation Code |
| IEER | Integrated energy efficiency ratio |
| IESNA | Illuminating engineering Society of North America |
| IHR | Ice Harvest Rate (lbs/day) |
| IPLV | Integrated Part-Load Value, a performance characteristic, typically of a chiller capable of capacity modulation. |
| k | Thermal conductivity |
| $kBTU/h_{in}$ | Input rating (kBTU/h) |
| $kBTU/h_{out}$ | Output rating (kBTU/h) |
| kgal | Thousand gallons |
| kSF | Thousand square feet |
| kW | kilowatts |
| l | Length |
| LBNL | Lawrence Berkeley National Laboratory |
| leakage | Estimate of percent of units not installed in service territory |
| LED | Light emitting diode |
| LEED | Leadership in Energy and Environmental Design |
| LF | Load Factor |
| Load | Average total weight (lbs) of clothes per drying cycle |
| LPD | Lighting power density |

| | |
|---|---|
| LRAC | Long-run avoided cost |
| LSAF | Load shape adjustment factor |
| MEC | Metropolitan Energy Center |
| min | Minutes |
| NACH | Natural Air Changes |
| NAECA | National Appliance Energy Conservation Act of 1987 |
| NBI | New Buildings Institute |
| NCEI | National Centers for Environmental Information |
| NEA | National Energy Alliances |
| NEAT | National Energy Audit Tool |
| NEMA | National Electrical Manufacturers Association |
| NREL | National Renewable Energy Laboratory |
| NRM | National Resource Management |
| NSTAR | Operating company of Northeast utilities |
| NWPPC | Northwest Power Planning Council |
| NWRTF | Northwest Regional Technical Forum |
| NY DPS | New York State Department of Public Service |
| NYISO | New York Independent System Operator |
| NYSERDA | New York State Energy Research and Development Authority |
| $^{o}F$ | Degrees Fahrenheit |
| OSA | Outdoor supply air |
| Pa | Pascals, the standard unit of pressure or stress in the International system of units (SI) |
| PA Consulting | PA Consulting Group |
| PF | Power factor |
| Phase | Number of phases in a motor (1 or 3) Single Phase is a type of motor with low horsepower that operates on 120 or 240 volts, often used in residential appliances. Three phase is a motor with a continuous series of three overlapping AC cycles offset by 120 degrees. Three-phase is typically used in commercial applications. |
| PLR | Power loss reduction |
| PNNL | Pacific Northwest National Laboratory |
| PSC | Public Service Commission, New York State |
| PSF | Proper sizing factor |
| psia | Atmospheric pressure (lbs per square inch) |
| psig | Gauge pressure (lbs per square inch) |
| PSZ | Packaged single zone |
| PTAC | Package terminal air conditioner |
| PTHP | Packaged terminal heat pump |
| Q | Heat |
| $Q_{reduced}$ | Reduced heat |
| $Q_{reject}$ | Total heat rejection |
| r | Radius |
| RA | Return air |

| | |
|---|---|
| RAC | Room air conditioner |
| RE | Recovery efficiency |
| RECS | Residential Energy Consumption Survey |
| RESNET | Residential Energy Services Network |
| RH | Reduced heat |
| RLF | Rated load factor |
| RPM | Revolutions per minute |
| R-value | A measure of thermal resistance particular to each material |
| S | Savings |
| SAPA | State Administrative Procedure Act |
| SBC | System Benefit Charge |
| SCFM | Standard cubic feet per minute @ 68 ºF and 14.7 psi standard condition |
| SEER | Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region) |
| SF | Square foot |
| SHGC | Solar heat gain coefficient |
| SL | Standby heat loss |
| Staff | NYS Department of Public Service Staff |
| standby | Standby Power (watts) |
| T | Temperature |
| TAF | Temperature adjustment factor |
| TDA | Total Display Area ($ft^2$) |
| TDEC | Total Daily Energy Consumption |
| TEFC | Totally enclosed fan cooled |
| th | Thickness |
| therm | Unit of heat |
| THR | Total heat rejection |
| $Throttle_{fac}$ | Throttle factor |
| TMY | Typical meteorological year |
| tons | Tons of air conditioning |
| tons/unit | Tons of air conditioning per unit, based on nameplate data |
| TRC | Total Resources Cost |
| TRM | Technical Resource Manual |
| UA | Overall heat loss coefficient (BTU/h-°F) |
| UA/L | Overall heat loss coefficient per unit length (BTU/h-°F-ft) |
| UEF | Uniform Energy Factor |
| unit | Measure |
| units | Number of measures installed under the program |
| UPC | Uniform Plumbing Code under the International Association of Plumbing and Mechanical Officials |
| US DOE | United States Department of Energy |
| US EPA | United States Environmental Protection Agency |
| U-value | Measure of heat loss in a building element/overall heat transfer co-efficient |
| V | Volt |

| | |
|---|---|
| v | Volume |
| VAV | Variable air volume |
| VSD | Variable speed drive |
| W | watts |
| $W_{ctrl}$ | Total wattage of controlled lighting (watts) |
| Wisconsin PSC | State of Wisconsin Public Service Commission |

| **EQUATION CONVERSION FACTORS** | |
|---|---|
| 0.000584 | Conversion factor used in DOE test procedure |
| 0.00132 | Electric efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume. |
| 0.0019 | Natural gas efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume. |
| 0.284 | Conversion factor, one kW equals 0.284 ton |
| 0.293 | Conversion factor, one BTU/h equals 0.293071 watt |
| 0.473 | Conversion factor (liters/pint) |
| 0.67 | Natural gas water heater Energy Factor |
| 0.746 | Conversion factor (kW/hp), 746 watts equals one electric horsepower |
| 0.97 | Electric resistance water heater Energy Factor |
| 1.08 | Specific heat of air × density of inlet air @ 70ºF × 60 min/hr |
| 1.6 | Typical refrigeration system kW/ton |
| 3.412 | Conversion factor, one watt-hour equals 3.412 BTU |
| 3.517 | Conversion factor, one ton equals 3.517 kilowatts |
| 8.33 | Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit |
| 12 | (kBTU/h)/ton of air conditioning capacity |
| 24 | Hours in one day |
| 67.5 | Ambient air temperature °F |
| 91 | Days in winter months |
| 100 | Conversion factor, one therm equals 100 kBTU |
| 274 | Days in non-winter months. |
| 365 | Days in one year |
| 3,412 | Conversion factor, one kWh equals 3,412 BTU |
| 8,760 | Hours in one year |
| 1,000 | Conversion factor, one kW equals 1,000 watts |
| 12,000 | Conversion factor, one ton equals 12,000 BTU/h |
| 100,000 | Conversion factor, (BTU/therm), one therm equals 100,000 BTU's |

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