Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-19-1	R	3/29/2019	1/1/2020	R/MF Air Leakage Sealing	Updated Measure Description to add detail regarding location and level of visual inspection and gut rehab exclusion; Added detail to derivation of variable terms; Updated F_h; Added detail to Compliance Efficiency section	Pg. 48
3-19-2	R	3/29/2019	1/1/2020	R/MF Opaque Shell Insulation	Clarified gut rehab exclusion in Measure Description; Updated reference to applicable code requirement in Compliance Efficiency section	Pg. 59
3-19-3	R	3/29/2019	1/1/2020	R/MF Window & Through-the-Wall Air Conditioner Cover and Gap Sealer	Added detail to Summary of Variables and Data Sources section regarding HDD derivation; Added detail to Compliance Efficiency section	Pg. 62
3-19-4	R	3/29/2019	1/1/2020	R/MF Storage Tank and Instantaneous Domestic Water Heater	Added detail to Measure Description on baseline equipment; Updated default Gallons Per Day of residential-duty commercial water heaters to reference default of the commercial version of this measure; Added language to the Baseline Efficiency section to clarify baseline values and assumptions; Updated Compliance Efficiency section to require ENERGY STAR® compliant equipment to qualify and added UEF tables; Revised Ancillary Electric Savings Impacts section for draft inducer fans	Pg. 84
3-19-5	R	3/29/2019	1/1/2020	R/MF Faucet – Low-Flow Aerator	Updated Measure Description to clarify code requirement; Updated variable terms and definitions for consistency with other measures; Updated default draw pattern assumption when unknown; Added language to the Baseline section to clarify calculation of UEF and included First Hour Rating vs Draw Pattern table; Added detail to Compliance Efficiency section	Pg. 91

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-19-6	R	3/29/2019	1/1/2020	R/MF Thermostatic Shower Restriction Valve	Updated Measure Description section; Updated default draw pattern assumption when unknown; Updated values and per unit savings; Updated variable terms for clarification; Added language to the Baseline section to clarify calculation of UEF and included First Hour Rating vs Draw Pattern table; Added detail to Compliance Efficiency section	Pg. 96
3-19-7	R	3/29/2019	1/1/2020	R/MF Showerhead – Low Flow	Revised Measure Description language for consistency with other measures; Updated default draw pattern assumption when unknown; Added language to the Baseline section to clarify calculation of UEF and included First Hour Rating vs Draw Pattern table; Added detail to Compliance Efficiency section	Pg. 102
3-19-11	R	3/29/2019	1/1/2020	C/I Steam Trap Repair or Replacement – Non-Space Heating Applications	Replaced “Other” with “Non-Space Heating” in Measure Title; Added language to clarify variable terms in Summary of Variables and Data Sources section; Updated Heat of Vaporization table to reflect values associated absolute pressure	Pg. 449

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between January 31, 2019 – March 29, 2019.

BUILDING SHELL

AIR LEAKAGE SEALING

Measure Description

This measure covers methods of sealing air leakage paths to reduce the natural air infiltration rate of a building through the installation of products and repairs to the building envelope, including, but not limited to, caulking, gasketing, and weather stripping. Sealing the thermal envelope reduces passive convective heat transfer between conditioned and unconditioned spaces or outside air, thereby reducing heating and cooling loads and improving occupant comfort. This measure is only applicable as a retrofit in existing buildings, excluding gut rehab/major renovation projects. These projects entail whole-building envelope alterations that trigger more stringent code provisions, limiting potential incremental savings.

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results and/or program eligibility requirements:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space
- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces, to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits.
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur.

An alternative method is provided below for estimation of savings for projects that conduct blower door testing before and after implementation of air sealing treatments. A blower door test is performed to measure the leakage rate by depressurizing the building to a standard pressure difference of 50 Pascals or 0.2 inches of water. The flowrate differential indicates the leakage rate, or infiltration and exfiltration rate, of the building shell.

Method for Calculating Annual Energy and Peak Coincident Demand Savings *(without blower door test)*

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings *(with blower door test)*

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta kWh}{CFM}\right)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta kW}{CFM}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta therms}{CFM}\right)$$

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
ΔCFM_{50}	= Change in infiltration rate (cubic foot per minute) before and after air leakage sealing as determined by blower door testing at a negative pressure differential of 50 Pa
F_n	= Zone correction for blower door infiltration rate to natural air changes
F_h	= Height correction for blower door infiltration rate to natural air changes
ΔkWh/CFM	= Annual electric energy savings per cubic foot per minute of reduced air leakage at 50 Pa
ΔkW/CFM	= Peak coincident demand electric savings per cubic foot per minute of reduced air leakage at 50 Pa
Δtherms/CFM	= Annual gas energy savings per cubic foot per minute of reduced air leakage at 50 P
ft^2	= Square feet
$\Delta kWh/1{,}000ft^2$	= Annual electric energy savings per thousand square feet
$\Delta kW/1{,}000ft^2$	= Peak coincident demand electric savings per thousand square feet
$\Delta therms/1{,}000ft^2$	= Annual gas energy savings per thousand square feet
CF	= Coincidence factor
1,000	= Conversion factor from ft^2 to 1,000 ft^2

Summary of Variables and Data Sources

Variable	Value	Notes
ΔCFM_{50}		From application, results from blower door test.
F_n	19	Value chosen from the range of 17-19 to reflect a conservative estimate of savings.[1]
F_h	1 story: 1.00 1.5 stories: 0.90 2 stories: 0.81 2.5 stories: 0.76 3+ stories: 0.70	Based on the number of conditioned stories in the building. [2] The selected value should reflect the number of stories located inside the conditioned envelope of the building. Unconditioned basements and attics should not be included. Half-story values are provided for upper levels without full height perimeter walls.
ΔkWh/CFM		Look up from Appendix E based on HVAC type and city.
ΔkW/CFM		Look up from Appendix E based on HVAC type and city.
Δtherms/CFM		Look up from Appendix E based on HVAC type and city.
ft^2		From application
$\Delta kWh/1{,}000ft^2$		Look up from Appendix E based on city and building vintage.
$\Delta kW/1{,}000ft^2$		Look up from Appendix E based on city and building vintage.
$\Delta therms/1{,}000ft^2$		Look up from Appendix E based on city and building vintage.
CF	0.69	

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a series of prototypical single and multifamily residential buildings. The prototype building characteristics are described in Appendix A. The unit energy and demand savings are shown in Appendix E.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[3]

Baseline Efficiencies from which Savings are Calculated

Baseline natural infiltration air changes per hour of 1.0 NACH for old vintage buildings and 0.5 NACH for average vintage buildings are assumed to estimate energy and demand savings tabulated in Appendix E.

[1] LBL, Estimation of Infiltration from Leakage and Climate Indicators, December 1986, pg. 84
[2] Ibid. The value for 2.5 stories was interpolated from presented data.
[3] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee.

A baseline SEER value of 13 and EER value of 11.1 are used in the simulations, as detailed in Appendix A, to estimate energy and demand savings tabulated in Appendix E.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the application of air leakage sealing treatments to an existing building envelope (excluding gut rehab/major renovations) such that the exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces have been inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results and/or program eligibility requirements:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space
- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces, to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits.
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Lawrence Berkeley Laboratory, Estimation of Infiltration from Leakage and Climate Indicators, Sherman, M. December 1986
   Available from: http://eta-publications.lbl.gov/sites/default/files/estimation_of_inflitration_from_leakage_and_climate_indicators.pdf
2. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
3. ECCCNYS 2016, per IECC 2015; Section C402.5.1.3 Air Barrier Testing
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency

4. NYCECC 2016; Section C402.5.1.3 Air Barrier Testing
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
5. ECCCNYS 2016, per IECC 2015; Section R402 Building Thermal Envelope
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency
6. NYCECC 2016; Section R402 Building Thermal Envelope
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016
7. 2017 NYS Uniform Code Supplement; Section 2.34 2015 IRC Section N1102.4.1 ((R402.4.1) Building thermal envelope)
   Available from:
   https://www.dos.ny.gov/DCEA/pdf/2017%20Uniform%20Code%20Supplement-10-2017.pdf
8. IMC 2015; Section 401.2 Ventilation Required
   Available from: https://codes.iccsafe.org/public/document/IMC2015NY-1/chapter-4-ventilation

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-25	7/31/2013
9-18-19	9/30/2018
12-18-2	12/28/2018
3-19-1	3/29/19

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<u>OPAQUE SHELL INSULATION</u>

Measure Description

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

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

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

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

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

Opaque shell insulation improvements performed under this measure shall be installed such that that all altered envelope components comply with all state, municipal and local code requirements

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

applicable to alterations to existing buildings, including but not limited to Section R503.1 of ECCCNYS 2016[2] and NYCECC 2016[3] requiring all existing ceiling, wall, and floor cavities exposed during construction to be filled with insulation. Thermal envelope components not altered as part of this measure (e.g. continuous insulation in wood-framed buildings) are not required to meet code for compliance.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. ECCCNYS 2016, per IECC 2015; Section R402 Building Thermal Envelope
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency
3. NYCECC 2016; Section R402 Building Thermal Envelope
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016

[2] ECCCNYS 2016, Section R402 Building Thermal Envelope
[3] NYCECC 2016, Section R402 Building Thermal Envelope

Record of Revision

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

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WINDOW AND THROUGH-THE-WALL AIR CONDITIONER COVER AND GAP SEALER

Measure Description

This measure covers the installation of a rigid, insulated cover installed on the inside of a room air conditioner (RAC) and a cover or sealing on the gap surrounding the unit. The cover is designed for RAC units, which are comprised of window air conditioners and through-the-wall air conditioners, left in place throughout the heating season and reduces heating load by limiting the infiltration of cold outside air. This measure is applicable in multifamily buildings only and building staff shall be instructed on proper annual removal and reinstallation to ensure persistence of savings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Heating Equipment Only)

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings (Gas Heating Equipment Only)

$$\Delta therms = units \times \frac{1.08 \times CFM \times HDD \times 24}{Eff_{heating} \times 100{,}000}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CFM	= Cubic foot per minute
HDD	= Heating degree day
$Eff_{heating}$	= Efficiency of heating system
1.08	= Specific heat of air × density of inlet air @ 70°F × 60 min/hr[1]
24	= Hours in one day
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU’s

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

Summary of Variables and Data Sources

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

Heating Degree Days

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

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

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

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

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

[2] Steven Winter Associates, There Are Holes in Our Walls, April 2011, pg 13
[3] TRANE Engineers Newsletter, Managing the Ins and Outs of Commercial Building Pressurization, 2002, pg 6. A conservative estimation of building pressure differential throughout New York State during the heating season.
[4] NYC Department of Housing Preservation and Development, Residential Heat and Hot Water Requirements
[5] HDD during heating season calculated from NOAA National Centers for Environmental Information

The baseline efficiency for heating systems serving single units is defined by the Code of Federal Regulations as shown in the table below.

Systems Serving Single Units[6]

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

The baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[7] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) and the New York City Energy Conservation Code[8] (NYCECC) as shown in the table below.

Systems Serving Multiple Dwelling Units

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

[6] 10 CFR 430.32(e)
[7] ECCCNYS 2016, Table C403.2.3(4) & Table C403.2.3(5)
[8] NYCECC 2016, Table C403.2.3(4) & Table C403.2.3(5)

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et	0.77 Et
	> 2,500 kBTU/h	0.77 Et	0.77 Et

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a room air conditioning unit in a multifamily building with a cover and/or sealing on the surrounding gap through the heating season (October 1st through May 31st).[9] Building staff shall be instructed on proper annual removal and reinstallation to ensure persistence of savings.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

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

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

3. ECCCNYS 2016, per IECC 2015; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements
Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
4. NYCECC 2016; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements
Available from:
https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
5. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
6. NYC Department of Housing Preservation and Development, Residential Heat and Hot Water Requirements
Available from: https://www1.nyc.gov/nyc-resources/service/1815/residential-heat-and-hot-water-requirements

Record of Revision

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

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STORAGE TANK AND INSTANTANEOUS DOMESTIC WATER HEATER

Measure Description

This measure covers the installation of storage tank water heaters designed to heat and store water at a thermostatically controlled temperature, as well as instantaneous type water heaters, which heat water but contain no more than one gallon of water per 4,000 BTU per hour of input. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating. Additionally, qualifying equipment must be designed to heat water to a temperature no greater than 180°F and, if electric power is required for operation, must use a single-phase external power supply.

Storage type units include residential gas storage water heaters with a nominal input of 75,000 BTU per hour or less and a rated storage capacity between 20 and 100 gallons, residential-duty commercial gas storage water heaters with a nominal input of greater than 75,000 BTU per hour and less than or equal to 105,000 BTU per hour and a rated storage capacity between 20 and 120 gallons and electric storage water heaters with an input of 12 kilowatts or less and a rated storage capacity between 20 and 120 gallons.

Instantaneous type units include gas instantaneous water heaters with a rated input capacity of greater than or equal to 50,000 and less than 200,000 BTU per hour and a manufacturer's specified storage capacity of less than 2 gallons, residential electric instantaneous water heaters with an input of 12 kilowatts or less and a manufacturer's specified storage capacity of less than 2 gallons and residential-duty commercial electric instantaneous water heaters with an input of greater than 12 kilowatts and less than or equal to 56.8 kilowatts and a manufacturer's specified storage capacity of 2 gallons or less.[1]

This measure applies to replacement of existing storage type and instantaneous water heaters using the same heating fuel (gas or electric) as the efficient case and assumes baseline to be a minimally code compliant water heater (as described in greater detail below) of the same type and heating fuel as the existing case. For new construction, this measure assumes baseline to be a minimally code compliant storage-type water heater using the same heating fuel (gas or electric) as the efficient case.

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

[1] Definitions of qualifying system types and specifications per 10 CFR 430.2 and revised in accordance with the limitations imposed by 10 CFR 430.32(d) and 10 CFR 431.110(b).

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Equipment Only)

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{UEF_{baseline}} - \frac{1}{UEF_{ee}}\right)$$

Peak Coincident Demand Savings (Electric Equipment Only)

$$\Delta kW = units \times \frac{(UA_{baseline} - UA_{ee}) \times \Delta T_{amb}}{3{,}412} \times CF$$

Annual Gas Energy Savings (Gas Equipment Only)

$$\Delta therms = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{UEF_{baseline}} - \frac{1}{UEF_{ee}}\right)$$

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
GPD	= Gallons per day
ΔT_{main}	= Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	= Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
UEF	= Uniform energy factor
UA	= Overall heat loss coefficient (BTU/h-°F)
CF	= Coincidence factor
365	= Days in one year
8.33	= Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[2] For residential-duty commercial water heaters, refer to GPD table in the commercial version of this measure.
ΔT_{main}	$T_{set} - T_{main}$	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F).
ΔT_{amb}	70 $= T_{set} - T_{amb}$	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F).
T_{set}	140	Water heater set point temperature (°F).[3]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
T_{amb}	70	Surrounding ambient air temperature (°F).[4]
$UEF_{baseline}$		Uniform Energy Factor of the baseline condition. See Baseline Efficiencies… section below for details regarding derivation of this input.
UEF_{ee}		Uniform Energy Factor of the energy efficient measure, from application.
$UA_{baseline}$		Overall heat loss coefficient of the baseline condition (BTU/h-°F).[5] For Instantaneous water heaters, set $UA_{baseline} = 0$. For storage type water heaters, set $UA_{baseline} = 7.85$.
UA_{ee}		Overall heat loss coefficient of the energy efficient measure (BTU/h-°F). For instantaneous water heaters, set $UA_{ee} = 0$. For storage type water heaters, set $UA_{ee} = 5.4$.[6]
CF	0.8	

[2] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
[3] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
[4] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.
[5] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was equated for two minimally code compliant gas storage water heaters found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 BTU/h assumed) and between 55 and 120 gallon capacity (75 gallon, 76,000 BTU/h assumed). Results of heat loss coefficient evaluation at these two data points agreed to within 0.3%, so the lower of the two was selected to represent the $UA_{baseline}$ term.
[6] Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory.

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

City	Annual average outdoor temperature[8] (°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 0.8.[9]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a minimally code compliant water heater of type (storage-type or instantaneous) equivalent to the existing water heater and with tank volume (where applicable), input capacity and draw pattern equivalent to the efficient water heater. For new construction, the baseline condition is a minimally code compliant storage-type water heater with tank volume, input capacity and draw pattern equivalent to the efficient water heater. For all instantaneous water heaters with a storage type baseline, a 40-gallon storage type water heater with input capacity and draw pattern equivalent to the efficient water heater shall be assumed.

$UEF_{baseline}$ shall be calculated as a function of qualifying equipment tank volume (v_t) for storage type water heaters or looked up for instantaneous water heaters per federal standards from the appropriate table (Residential Water Heaters or Residential-Duty Commercial Water Heaters) below, using the baseline equipment type and efficient case capacity and draw pattern. Draw pattern can be established based on the efficient equipment First Hour Rating (FHR), rated in gallons, for storage type water heaters or Max Gallons per Minute (GPM), rated in gallons/minute, for instantaneous water heaters. See the First Hour Rating vs. Draw Pattern and Max GPM vs. Draw Pattern tables below for storage type and instantaneous water heaters, respectively. If FHR or Max GPM 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.[10]

[7] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[8] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals
[9] *No source specified – update pending availability and review of applicable references.*
[10] 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[11]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.3456 - (0.0020 \times v_t^*)$
		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 ≤ 120 gal	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

*v_t = tank volume in gallons

Residential-Duty Commercial Water Heaters[12]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	> 75,000 BTU/h and ≤ 105,000 BTU/h and ≤ 120 gal	Very Small	$0.2674 - (0.0009 \times v_t^*)$
		Low	$0.5362 - (0.0012 \times v_t)$
		Medium	$0.6002 - (0.0011 \times v_t)$
		High	$0.6597 - (0.0009 \times v_t)$

[11] 10 CFR 430.32(d)
[12] 10 CFR 431.110(b)

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Instantaneous Electric Water Heater	> 12 kW gal and ≤ 55 gal	Very Small	0.80
		Low	0.80
		Medium	0.80
		High	0.80

*v_t = tank volume in gallons

First Hour Rating vs. Draw Pattern (Storage Type Only)[13]

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

Max GPM vs. Draw Pattern (Instantaneous Only)[14]

Max GPM	Draw Pattern
< 1.7 gallons/minute	Very Small
≥ 1.7 and < 2.8 gallons/minute	Low
≥ 2.8 and < 4.0 gallons/minute	Medium
≥ 4.0 gallons/minute	High

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® rated gas or electric storage or gas instantaneous type water heater, or an electric instantaneous type water heater as directed by program eligibility criteria. Efficient gas and electric storage tank water heaters and gas instantaneous type water heaters must be eligible under ENERGY STAR® Program Requirements for Residential Water Heaters, Eligibility Criteria Version 3.2, effective April 2015.[15] Minimum UEF qualification for ENERGY STAR® equipment are shown in the table below.

[13] 10 CFR 429.17
[14] 10 CFR 429.17
[15] ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria, Version 3.2, April 16, 2015

Residential Water Heaters

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	UEF
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Medium	≥ 0.64
		High	≥ 0.68
	> 55 gal and ≤ 100 gal	Medium	≥ 0.78
		High	≥ 0.80
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Low	≥ 2.00
		Medium	≥ 2.00
		High	≥ 2.00
	> 55 gal and ≤ 100 gal	Low	≥ 2.20
		Medium	≥ 2.20
		High	≥ 2.20
Instantaneous Gas-fired Water Heater	< 2 gal and > 50,000 BTU/h	Medium	≥ 0.87
		High	≥ 0.87

Residential-Duty Commercial Water Heaters

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	UEF
Gas-Fired Storage Water Heater	> 75,000 BTU/h and ≤ 105,000 BTU/h and ≤ 120 gal	Low	≥ 0.80
		High	≥ 0.80
		Medium	≥ 0.80

Operating Hours

Water heater run hours are not utilized in the estimation of energy or demand savings, but water heater is assumed to be available for operation 8,760 hours per year. Additionally, it is assumed standby losses are incurred 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction in standby heat losses will have a negligible impact on space heating when the water heater is located in conditioned space. Consideration of these effects is not included in this methodology.

Ancillary Electric Savings Impacts

Reduction in standby heat losses will have a negligible impact on space heating and cooling when the water heater is located in conditioned space. Consideration of these effects is not included in this methodology.

Gas water heaters with draft inducer fans may introduce additional electric load. Consideration of this effect is not included in this methodology.

References

1. ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria, Version 3.2, April 16, 2015
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3. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
4. 10 CFR 431.110 Energy conservation standards and their effective dates.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=a69096e892b13c204bbe6da3a92f8111&mc=true&node=se10.3.431_1110&rgn=div8
5. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016
   Available from: http://www.waterrf.org/PublicReportLibrary/4309A.pdf
6. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from:
   https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
7. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
8. 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters
   Available from:
   https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf
9. AHRI Directory of Certified Product Performance
   Available from: https://www.ahridirectory.org/ahridirectory/pages/home.aspx
10. 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;jsessionid=05D73BA6EF5ECCF71969D083FB317991?doi=10.1.1.515.6885&rep=rep1&type=pdf
11. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
    Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

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

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-13-1	6/30/2013
7-13-6	7/31/2013
11-13-2	11/26/2013
12-17-5	12/31/2017
3-19-4	3/29/2019

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DOMESTIC HOT WATER – CONTROL

FAUCET – LOW-FLOW AERATOR

Measure Description

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 municipal and local codes and standards. New York City plumbing code and New York State construction code 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 Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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

$$H_2O_{savings} = (GPM_{baseline} - GPM_{ee}) \times Throttle_{fac} \times \frac{minutes}{use} \times \frac{uses}{day} \times 365\frac{days}{yr}$$

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
T	= Temperature (°F)
UEF	= Uniform energy factor
GPM	= Gallon per minute
$Throttle_{fac}$	= Throttle factor
8.33	= Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}	1.5	GPM for energy efficient measure, from application (Non-lavatory faucets)
	1.0	GPM for energy efficient measure, from application (Lavatory faucets)
$GPM_{baseline}$	2.2	GPM for baseline measure (Non-lavatory faucets) [1,2]
	1.5	GPM for baseline measure (Lavatory faucets)
$Throttle_{fac}$	0.75	Average percent of full capacity that the faucet valve is opened when in use.
minutes/use	0.5	Estimated duration of use (based on approximately 8.5 minutes of usage per faucet per day; assumes 26 minutes of faucet usage per household per day and 3 faucets per household)[3]
uses/day	17	Estimated number of uses per day (based on approximately 8.5 minutes of usage per faucet per day; assumes 26 minutes of faucet usage per household per day and 3 faucets per household)[4]
$H_2O_{savings}$	1,629	Calculated gallons of water saved per year based on installation of energy efficient measure (Non-lavatory faucets)
	1,163	Calculated gallons of water saved per year based on installation of energy efficient measure (Lavatory faucets)
T_{faucet}	80	The typical water temperature leaving the faucet in °F
T_{main}		Average inlet water temperature (see appending table) (°F)
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern)[5]

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

City	Annual average outdoor temperature[7] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5

[1] 2017 NYS Uniform Code Supplement, Table P2903.2
[2] 2014 NYC Plumbing Code, Table 604.4
[3] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016
[4] Ibid.
[5] 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)
[6] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[7] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

City	Annual average outdoor temperature[7] (°F)	T_{main} (°F)
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 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 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.[8] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a 40-gallon, 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	$0.8072 - (0.0003 \times V_t)$

[8] 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[9]	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[10]

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

Operating hours are assumed at 365 days per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

[9] For informational purposes only: UEF values for electric storage water heaters > 55 gallons and ≤ 100 gallons imply this equipment heat pump water heaters
[10] 10 CFR 429.17

Ancillary Electric Savings Impacts

N/A

References

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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

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THERMOSTATIC SHOWER RESTRICTION VALVE

Measure Description

A thermostatic valve 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. This measure is applicable to valves installed in residential applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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
(Δtherm/unit) = Annual gas energy savings per unit
CF = Coincidence factor

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).
(Δtherm/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).

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]
Showers/day	2	Calculated from LBNL study based on assumption of 2.59 persons/household and 0.75 showers per day per capita[3]
T_{main}		Average inlet water temperature (°F) by location is shown below.
T_{shower}	104	Average temperature at showerhead[4]
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. [5] 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.[6] See Residential Water Heaters table below for calculating UEF for specific system types.

kWh Savings (ΔkWh/unit)

Location	Flow Rate (GPM)				
	1	**1.25**	**1.5**	**1.75**	**2**
Albany	85	107	128	149	170
Binghamton	89	111	133	155	177
Buffalo	85	107	128	149	170
Massena	93	117	140	164	187
NYC	73	91	110	128	146
Poughkeepsie	83	103	124	145	165
Syracuse	85	107	128	149	170

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:

[1] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[2] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014
[3] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[4] Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014
[5] 10 CFR 430.32(d)
[6] Ibid.

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

Therm Savings (Δtherm/unit)

Location	Flow Rate (GPM)				
	1	1.25	1.5	1.75	2
Albany	4.6	5.8	6.9	8.1	9.2
Binghamton	4.8	6.0	7.2	8.4	9.6
Buffalo	4.6	5.8	6.9	8.1	9.2
Massena	5.1	6.3	7.6	8.8	10.1
NYC	4.0	4.9	5.9	6.9	7.9
Poughkeepsie	4.5	5.6	6.7	7.8	8.9
Syracuse	4.6	5.8	6.9	8.1	9.2

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:

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

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

City	Annual average outdoor temperature[8] (°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.

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

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

Baseline Efficiencies from which 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 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.[9] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a 40-gallon, 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	$0.8072 - (0.0003 \times V_t)$
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 [10]	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

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

[10] Electric Storage Water Heaters > 55 gallons and ≤ 100 gallons are 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[11]

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

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

[11] 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. 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
4. Lawrence Berkeley National Laboratory (LBNL): "Water and Energy Wasted During Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems", September 2011
   Available from:
   https://efficiency.lbl.gov/sites/all/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_water_distribution_systems_lbnl-5115e.pdf
5. Pilot Study for a Thermostatic Shower Restriction Valve, Cadmus, 2014
   Available from: https://www.iepec.org/wp-content/uploads/2015/papers/164.pdf
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. Uniform Plumbing Code (UPC) certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a.
10. 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
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
6-14-2	6/19/2014
6-17-3	6/30/2017
3-19-6	3/29/2019

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SHOWERHEAD – LOW FLOW

Measure Description

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, municipal and local codes and standards. New York City plumbing code and New York State construction code 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 Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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

$$H_2O_{savings} = (GPM_{baseline} - GPM_{ee}) \times Throttle_{fac} \times \frac{minutes}{use} \times \frac{uses}{day} \times 365\frac{days}{yr}$$

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
T	= Temperature (°F)
UEF	= Uniform energy factor
GPM	= Gallon per minute
$Throttle_{fac}$	= Throttle factor
8.33	= Energy required (BTU’s), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU’s
3,412	= Conversion factor, one kW equals 3,412 BTU/h

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[1,2]
$Throttle_{fac}$	0.9	Used in LBNL study to adjust for occupant reduction in flow rate[3]
minutes/use	8.2	Average shower duration per LBNL study.[4]
uses/day	2	Calculated from LBNL study based on assumption of 2.59 persons/household and 0.75 showers per day per capita.[5]
T_{main}		Average inlet water temperature (˚F) by location is shown below.
T_{shower}	105	Average temperature at showerhead (˚F); conservative assumption based on 2014 NYS plumbing code, EPA MFHR program and ASSE 1070-2014
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume medium draw pattern)[6]

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

City	Annual average outdoor temperature[8] (°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

1 2017 NYS Uniform Code Supplement, Table P2903.2
2 2014 NYC Plumbing Code, Table 604.4
3 LBNL: Potential Water and Energy Savings from Showerheads, March 2006
4 Ibid.
5 Ibid.
6 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)
7 Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
8 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

Coincidence Factor (CF)

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

Baseline Efficiencies from which 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 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.[9] If the type of existing water heater cannot be identified due to program delivery mechanism, assume a 40-gallon, Medium draw storage type system with primary water heater fuel from application.

<u>Residential Water Heaters</u>

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 [10]	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	$2.2418 - (0.0011 \times V_t)$

[9] Based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[10] Electric Storage Water Heaters > 55 gallons and ≤ 100 gallons are Heat Pump water heaters

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Uniform Energy Factor
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[11]

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

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. [12]

Operating Hours

Estimate of energy savings assumes 2 showers per day with an average duration of 8 minutes, 12 seconds per shower event.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

[11] 10 CFR 429.17
[12] Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory

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
4. 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
5. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
6. 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
7. EPA WaterSense® Partnership Program
   Available from: https://www.epa.gov/watersense/partners-directory

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

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PROCESS EQUIPMENT

STEAM TRAP REPAIR OR REPLACEMENT – NON-SPACE HEATING APPLICATIONS

Measure Description

Steam systems distribute heat from boilers to satisfy space heating, process, and commercial end-use requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements. This measure and calculations are applicable to steam traps served by gas fired boilers, for low, medium, and high pressure (0-3,000 psig) non-space heating steam applications, where flash steam on the condensate side of steam traps is not utilized for other heating processes. These steam applications include but are not limited to: space reheat, steam humidifiers, high pressure PRV stations, medium pressure PRV stations, and steam to hot water heat exchangers. This measure does not apply to municipal steam systems.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to ensure correct operation. Faulty steam traps (leaking or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam production. There are three major types of steam traps that are applicable: 1) thermostatic (including float and thermostatic) 2) mechanical and 3) thermodynamic traps. A system-wide assessment of steam trap operation and functionality is required for this measure and estimated energy savings is restricted to the repair or replacement of faulty traps only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times Loss_{steam} \times \frac{\Delta H_{vap}}{Eff} \times \frac{hrs}{100{,}000}$$

$$Loss_{steam} = 24.24 \times Dia^2 \times P_a \times F_{derate}$$

$$P_a = psig + psia$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of steam traps repaired/replaced under the program
$Loss_{steam}$	= Hourly steam loss per failed trap (lb/hr)
24.24	= Steam loss constant per Napier's equation (lb/hr-psia-in^2)
Dia	= Internal Diameter (I.D.) of steam trap orifice (inches)
P_a	= Absolute steam pressure (psi)
F_{derate}	= Aggregate derating factor
psig	= Steam gauge pressure (psi)
psia	= Atmospheric pressure (psi) where system is vented and not a pressurized or vacuum condensate return system; otherwise, psia should be established such that P_a reflects the pressure differential between the inlet and outlet of the steam trap
ΔH_{vap}	= Heat of vaporization (latent heat), in BTU/lb, at system operating pressure (psig)
Eff	= Efficiency of boiler
hrs	= Annual hours of steam trap operation
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$		Calculated per the equation above, dependent upon system operating pressure (psig) and steam trap orifice diameter (Dia).
Dia		From application.
P_a		Calculated per the equation above, dependent upon system operating pressure (psig).
Psig		From application.
Psia		Atmospheric pressure (14.7 psi) where system is vented and not a pressurized or vacuum condensate return system; otherwise, psia should be established such that P_a reflects the pressure differential across the steam trap.
F_{derate}	0.32	Aggregate derating factor accounts for the average percentage of time the trap fails in the open position as well as actual vs. theoretical energy loss. [1]
ΔH_{vap}		Look up from table below based on system operating pressure (psig).
Eff		Boiler efficiency, from application. Either E_t or AFUE shall be used, based on nameplate rating metric of existing equipment or actual system efficiency as provided on the application and documented by the customer.

[1] Focus on Energy Evaluated Deemed Savings Changes, August 2017, pg 11, footnote 13

Variable	Value	Notes
hrs		From application. If unknown, use a default of 8,424 for industrial applications[2] and 2,425 for dry cleaners.[3]

Heat of Vaporization (BTU/lb)[4]

Pressure (psig)	Heat of Vaporization (BTU/lb)	Pressure (psig)	Heat of Vaporization (BTU/lb)	Pressure (psig)	Heat of Vaporization (BTU/lb)
0	970	**70**	898	**500**	752
1	968	**75**	895	**550**	740
2	966	**80**	892	**600**	729
3	964	**85**	889	**700**	707
4	962	**90**	886	**800**	686
5	961	**95**	884	**900**	667
6	959	**100**	881	**1,000**	647
7	957	**110**	876	**1,100**	584
8	956	**120**	871	**1,200**	354
9	954	**130**	866	**1,300**	591
10	953	**140**	862	**1,400**	573
15	946	**150**	857	**1,500**	555
20	940	**160**	853	**1,600**	536
25	934	**170**	849	**1,700**	518
30	929	**180**	845	**1,800**	500
35	924	**190**	842	**1,900**	481
40	920	**200**	838	**2,000**	462
45	916	**250**	821	**2,250**	412
50	912	**300**	805	**2,500**	357
55	908	**350**	791	**2,750**	293
60	905	**400**	777	**3,000**	209
65	901	**450**	764		

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline is assumed to be a leaking or blow-through steam trap failed open on a non-space heating steam system.

[2] Assumes constant operation except for 2 weeks out of the year when boilers are often shutoff for maintenance
[3] CLEAResult “Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012. The CLEAResults Work Paper is not publicly available, but is referenced by the Illinois TRM Version 6, pg 214
[4] Values in this table were calculated from NIST Standard Reference Database 10, “NIST/ASME Steam Properties,” Ver. 2.11, National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, 1997

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an intact (replaced or repaired) steam trap on a non-space heating steam system. Replaced or repaired steam traps will no longer leak or blow-through after installation.

Operating Hours

Operating hours of steam trap system are assumed to be 8,424[5] for industrial and process applications and 2,425[6] for steam traps used in dry cleaners.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Illinois Technical Reference Manual, Version 6, February 8, 2017
   Available from: http://www.ilsag.info/il_trm_version_6.html
2. Joseph Henry Keenan and Frederick G. Keyes, Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases, John Wiley and Sons, New York (1936)
3. "NIST/ASME Steam Properties," Ver. 2.11, National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, 1997
4. Focus on Energy Evaluated Deemed Savings Changes, Public Service Commission of Wisconsin, August 2017
   Available from:
   https://www.focusonenergy.com/sites/default/files/FoE_Deemed%20Savings%20Report_%20CY%2017_v1.7.pdf

[5] Assumes constant operation except for 2 weeks out of the year when boilers are often shutoff for maintenance

[6] CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012, Work Paper not publicly available, but reported in Illinois TRM Version 6, pg 214

Record of Revision

Record of Revision Number	Issue Date
9-18-17	9/28/2018
3-19-11	3/29/2019

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