Table of Revisions/Changes

Revision Number	Addition/Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-23-1	R	3/31/2023	1/1/2024	R/MF Air Conditioner - Room (RAC) Recycling)	Language to clarify that unit(s) must be removed from operation to avoid unit sales on secondary market.	Pg. 60
3-23-2	R	3/31/2023	1/1/2024	R/MF Dehumidifier Recycling	Language to clarify that unit(s) must be removed from operation to avoid unit sales on secondary market.	Pg.65
3-23-3	R	3/31/2023	1/1/2024	R/MF Refrigerator and Freezer Recycling	Language to clarify that unit(s) must be removed from operation to avoid unit sales on secondary market	Pg.69
3-23-4	R	3/31/2023	1/1/2024	R/MF Insulation - Hot Water and Steam Pipe	Savings for CPVC/PEX piping added.	Pg.85
3-23-8	R	3/31/2023	1/1/2024	R/MF Energy and Heat Recovery Ventilator	Updating compliance specifications for residential applications. Q1 2023 review batch to accommodate the establishment of technical specifications based on either AHRI Standard 1060 (commercial-duty) or HVI Publication 920/CSA-C439 (residential-duty).	Pg.222
3-23-9	R	3/31/2023	1/1/2024	R/MF Heat Pump - Air Source (ccASHP)	Changed downstate ASHP parameter from rated to max capacity; removed SEER2/HSPF2 baseline tables and included conversion method; updated control scenarios and impact factors	Pg.234
3-23-10	R	3/31/2023	1/1/2024	R/MF Thermostat - Wi-Fi (Communicating)	Addition of language clarifying HVAC system must have a/c component or be a heat pump.	Pg.318
3-23-11	R	3/31/2023	1/1/2024	R/MF Interior and Exterior Lighting	LMI LED Table of Hours per Day by Unit Count explanation added.	Pg.336
3-23-12	R	3/31/2023	1/1/2024	C/I Air Conditioner - Room (RAC) Recycling	Language added to clarify that unit(s) must be removed from operation to avoid unit sales on secondary market.	Pg.502
3-23-14	R	3/31/2023	1/1/2024	C/I Insulation - Hot Water and Steam Pipe	Savings for CPVC/PEX piping added.	Pg.532
3-23-15	R	3/31/2023	1/1/2024	C/I Energy and Heat Recovery Ventilator	Updating compliance specifications for residential applications. Q1 2023 review batch to accommodate the establishment of technical specifications based on either AHRI Standard 1060 (commercial-duty) or HVI Publication 920/CSA-C439 (residential-duty).	Pg.710

Revision Number	Addition/Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-23-16	R	3/31/2023	1/1/2024	C/I Heat Pump - Air Source (ccASHP)	Changed downstate ASHP parameter from rated to max capacity; removed SEER2/HSPF2 baseline tables and included conversion method; updated control scenarios and impact factors	Pg.721
3-23-17	R	3/31/2023	1/1/2024	C/I Energy Management System (EMS) - Guest Room	Adjustment of savings numbers for Electric Savings factor, Fossil Fuel Energy Savings Factor, and Demand Savings Factors.	Pg.828
3-23-18	R	3/31/2023	1/1/2024	C/I Thermostat - Wi-Fi (Communicating)	Addition of language clarifying HVAC system must have a/c component or be a heat pump.	Pg.858
3-23-21	R	3/31/2023	1/1/2024	Appendix P	Updated EUL for measures included in this ROR	Pg.1355
3-23-22	R	3/31/2023	1/1/2024	Appendix Q	Peak Load Shape Factors added for NYSEG/RG&E territories.	Pg.1372

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between January 01, 2023 – March 31, 2023.

APPLIANCE RECYCLING

AIR CONDITIONER - ROOM (RAC) RECYCLING

Measure Description

In many cases where an air conditioning unit is replaced by a homeowner, the existing unit is retained, sold, or donated for use elsewhere and represents additional load on the grid. This measure covers recycling of the existing functional equipment, thereby eliminating the consumption associated with that equipment. Air conditioner recycling programs receive energy savings credit for permanently removing inefficient functional air conditioners from the electric grid.

This measure covers the recycling of inefficient room air conditioners in residential applications. A room air conditioner is a consumer product, other than a "packaged terminal air conditioner," which is powered by a single phase electric current, and which is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating.[1] Minimum energy conservation standards for these appliances have been established by the Code for Federal Regulations 10 CFR 430.32(b). As this standard continues to be revised, and by association ENERGY STAR® standards continue to increase, operational savings attributable to new RAC may justify early retirement before the full useful life has been exhausted. To realize the anticipated savings, a currently functioning appliance 5 years old or older of equivalent cooling capacity and type must be properly disposed of when a new appliance is supplied to the customer.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times EFLH_{cooling}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

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

[1] 10 CFR 430.2.

ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures recycled under the program
(BTU/h)/unit	= British Thermal Units per hour of air conditioning per unit
$_{baseline}$	= Characteristic of baseline condition
CEER	= Combined Energy Efficiency Ratio
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
(BTU/h)/unit		From application, or use 7,829 as default.[2]
$CEER_{baseline}$		If known, use the nameplate efficiency of the recycled equipment, from application. Nameplate EER may be converted to CEER by dividing EER by 1.01 (EER/1.01 = CEER).[3] If unknown, see Baseline Efficiencies section below.
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup from Operating Hours section below based on location.
CF	0.3	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.3.[4] The average Seasonal CF based on 2007 weather data used for this measure aligns with results of a sampling study conducted in Con Edison territory, citing a CF = 0.31.[5]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is equivalent to the existing equipment. $CEER_{baseline}$ shall be set equal to the nameplate efficiency of the existing unit, converted from EER to CEER via the conversion CEER = EER/1.01, if necessary. If nameplate efficiency is unavailable, use the rated efficiency ratio based on recycled equipment manufacture date, type and capacity per the table below.

[2] RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008, p. 22 (based on population average).
[3] Conversion factor developed by comparing EER and CEER values reported in ENERGY STAR® Program Requirements for Room Air Conditioners Version Eligibility Criteria 3.1.
[4] RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008, p. iv (based on average Seasonal CF for all load zones using 2007 weather data).
[5] Northeast Energy Efficiency Partnerships, Loadshape Report and Catalogue.

Recycled Equipment Manufactured Before June 2014

The CEER values listed in the table below reflect the minimum performance required by the Code of Federal Regulations effective October 1, 2000, to May 31, 2014.[6]

Product Type	Product Class Capacity (BTU/h)	Federal Standard With Louvered Sides (CEER)	Federal Standard Without Louvered Sides (CEER)
RAC without Reverse Cycle	< 6,000	9.6	8.9
	6,000 to 7,999	9.6	8.9
	8,000 to 10,999	9.7	8.4
	11,000 to 13,999	9.7	8.4
	14,000 to 19,999	9.6	8.4
	20,000 to 27,999	8.4	8.4
	≥ 28,000	8.4	8.4
RAC with Reverse Cycle	< 14,000	8.9	8.4
	14,000 to 19,999	8.9	7.9
	≥ 20,000	8.4	7.9
Casement Only	All	8.6	
Casement-Slider	All	9.4	

Recycled Equipment Manufactured After June 2014

The CEER values listed in the table below reflect the minimum performance required by the Code of Federal Regulations effective June 1, 2014.[7]

Product Type	Product Class Capacity (BTU/h)	Federal Standard With Louvered Sides (CEER)	Federal Standard Without Louvered Sides (CEER)
RAC without Reverse Cycle	< 6,000	11.0	10.0
	6,000 to 7,999	11.0	10.0
	8,000 to 10,999	10.9	9.6
	11,000 to 13,999	10.9	9.5
	14,000 to 19,999	10.7	9.3
	20,000 to 27,999	9.4	9.4
	≥ 28,000	9.0	9.4
RAC with Reverse Cycle	< 14,000	9.8	9.3
	14,000 to 19,999	9.8	8.7
	≥ 20,000	9.3	8.7
Casement Only	All	9.5	
Casement-Slider	All	10.4	

[6] 10 CFR 430.32(b), CFR EER values were converted to CEER values by dividing by 1.01. Conversion factor developed by comparing EER and CEER values reported in ENERGY STAR® Program Requirements for Room Air Conditioners Version Eligibility Criteria 4.1.
[7] 10 CFR 430.32(b)

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the recycling of an existing room air conditioner as defined in the Measure Description section above.

Operating Hours

Cooling equivalent full load hours for residential room air conditioners shall be established based on location per the table below. $EFLH_{cooling}$ values below were determined by calculating the ratio of RAC cooling EFLH in Albany[8] to average cooling EFLH in Albany per Appendix G and applying it to the average EFLH for each city. EFLH was averaged from Appendix G over vintage and building type for each city.

City	$EFLH_{cooling}$
Albany	259
Binghamton	175
Buffalo	266
Massena	204
NYC	338
Poughkeepsie	345
Syracuse	251

Example Calculation *(Not to be used as default)*

A single-family homeowner located near Massena recycles an existing functional air conditioning unit manufactured in 2012 with 7,800 BTU/h capacity and louvered sides. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident. Demand Savings are calculated as below.

$$\Delta kWh = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times EFLH_{cooling}$$

$$\Delta kW = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times CF$$

units = 1, from application
(BTU/h)/unit = 7,800 BTU/h, from application
$CEER_{baseline}$ = 9.6, from Baseline Efficiencies section based on Manufacture Date, Product Type, and Capacity
$EFLH_{cooling}$ = 204, from Operating Hours section based on location
CF = 0.3, from Summary of Variables and Data Sources table

$$\Delta kWh = 1 \times \frac{7{,}800}{1{,}000} \times \frac{1}{9.6} \times 204 = 165.75 \text{ kWh}$$

[8] RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008, p. iv (based on 2007 FLEH for Albany).

$$\Delta kW = 1 \times \frac{7{,}800}{1{,}000} \times \frac{1}{9.6} \times 0.3 = 0.24\ kW$$

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=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12
2. RLW Analytics, Final Report Coincidence Factor Study: Residential Room Air Conditioners. June 23, 2008.
   Available from:
   http://www.puc.state.nh.us/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf
3. ENERGY STAR® Program Requirements, Product Specification for Room Air Conditioners, Eligibility Criteria, Version 4.0, February 2015.
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%204.0%20Room%20Air%20Conditioners%20Specification.pdf
4. Northeast Energy Efficiency Partnerships, Loadshape Report and Catalogue.
   Available from: http://neep.org/loadshape-report-and-catalogue
5. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_132

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-37	7/31/2013
3-18-8	3/29/2018
3-23-1	3/31/2023

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APPLIANCE RECYCLING

DEHUMIDIFIER RECYCLING

Measure Description

When a dehumidifier is replaced by a homeowner, the existing unit may be retained, sold or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of existing, functional, portable dehumidifiers, thereby eliminating the consumption associated with that equipment.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times capacity \times \frac{0.473}{24} \times hrs \times \frac{1}{L/kWh}$$

Summer Peak Coincident Demand Savings

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

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fossil fuel energy savings
units = Number of measures recycled under the program
capacity = Capacity of the unit (pints/day)
hrs = Annual operating hours
L/kWh = Dehumidifier efficiency (L/kWh)
CF = Coincidence Factor
0.473 = Conversion factor to convert pints to liters
24 = Constant to convert liters/day to liters/hour

Summary of Variables and Data Sources

Variable	Value	Notes
capacity		From application.
L/kWh		Liters of water removed per kWh consumed, as provided in the Baseline Efficiencies section below.

Variable	Value	Notes
hrs	1,632	Run hours based on 68 days per year, 24 hours of use.[9]
CF	0.56	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.56.[10]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is equivalent to the existing equipment. If specific equipment efficiency is unavailable, use the dehumidifier efficiency based on manufacture date and capacity from the equipment nameplate, and ENERGY STAR® labeling status per the table below.

Capacity Range (pints/day)	ENERGY STAR® Labeled (L/kWh)[11]	Non- ENERGY STAR® Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)[12]	Manufacture date of Oct. 2012 or later (≥L/kWh)[13]
≤ 25	1.57	1.00	1.35
> 25 to ≤ 35	1.80	1.20	1.35
> 35 to ≤ 45	1.80	1.30	1.50
> 45 to ≤ 50	1.80	1.30	1.60
> 50 to ≤ 54	3.30	1.30	1.60
> 54 to ≤ 75	3.30	1.50	1.70
> 75	3.30	2.25	2.50

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the recycling of an existing dehumidifier as defined in the Measure Description section above.

Operating Hours

The dehumidifier is assumed to be operating 1,632 hours per year based on 68 days of 24 hour operation.[14]

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[9] Savings Calculator for ENERGY STAR® Qualified Appliances (accessed 05/11/2021).
[10] A. Mendyk & D. Cautley, Dehumidifier Metering Study, Home Energy, January 2011: Summer duty cycle used as a proxy for CF.
[11] ENERGY STAR® Program Requirements for Dehumidifiers, Version 5.0, February 2019.
[12] 42 U.S.C, Title 42 Chapter 77, Subchapter III, Part A, (cc)(1).
[13] Ibid, (cc)(2).
[14] Savings Calculator for ENERGY STAR® Qualified Appliances (accessed 05/11/2021).

Example Calculation *(Not to be used as default)*

An existing residential customer in Albany recycles an operational dehumidifier with 30 pints/day capacity. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times capacity \times \frac{0.473}{24} \times hrs \times \frac{1}{L/kWh}$$

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

Units	= 1, from application
capacity	= 30 pints/day, from application
hrs	= 1,632 hours, from operating hours section
L/kWh	= 1.25 L/kWh, from application
CF	= 0.56, from Summary of Variables and Data sources table

$$\Delta kWh = 1 \times 30 \times \frac{0.473}{24} \times 1{,}632 \times \frac{1}{1.25} = 771.94\ kWh$$

$$\Delta kW = \frac{771.94}{1{,}632} \times 0.56 = 0.26\ kW$$

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. A. Mendyk & D. Cautley, Dehumidifier Metering Study, Home Energy, January 2011.
   Available from: http://www.homeenergy.org/show/article/id/777
2. 42 U.S.C, Title 42 Chapter 77, Subchapter III, Part A.
   Available from: https://www.govinfo.gov/content/pkg/USCODE-2016-title42/html/USCODE-2016-title42-chap77-subchapIII-partA-sec6295.htm

3. Savings Calculator for ENERGY STAR® Qualified Appliances.
   Available from: https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/energy-star-appliance-calculator.xlsx
4. ENERGY STAR® Program Requirements for Dehumidifiers, Version 5.0, February 2019.
   Available from: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20Version%205.0%20Program%20Requirements_0.pdf

Record of Revision

Record of Revision Number	Issue Date
7-21-2	8/30/2021
6-22-3	9/2/2022
3-23-2	3/31/2023

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APPLIANCE RECYCLING

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 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 also covers 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.[15]

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

$$\Delta kW = units \times \left(\frac{\Delta kWh}{8{,}760}\right) \times TAF \times LSAF \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures recycled under the program

[15] 10 CFR 430.2.

(ΔkWh/unit)	= Gross deemed annual electric savings per unit
TAF	= Temperature Adjustment Factor
LSAF	= Load Shape Adjustment Factor
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.[16]

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: 958 Secondary Refrigerator: 581 Freezer: 593 Compact Refrigerators, Refrigerator-Freezers and Freezers: See table below	Look up compact unit from Compact Refrigerator, Refrigerator-Freezer and Freezer table based on product type. Otherwise, Refrigerator and Freezer based on Appliance Recycling Program Impact Evaluation.[17]
TAF	1.22	Temperature Adjustment Factor; reflects load variance during summer peak due to increased ambient temperature conditions.[18]
LSAF	1.06	Load Shape Adjustment Factor; reflects the instantaneous differential from annual average load coincident with peak.[19]
CF	0.96	

[16] NREL, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. January 2010-September 2016. Chapter 7: Refrigerator Recycling Evaluation Protocol.
[17] Appliance Recycling Program Impact Evaluation, study prepared by DNV.
[18] 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.
[19] Ibid.

For equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer", ΔkWh/unit shall be derived based on the Product Class and internal volume in cubic feet (AV) from the table below reflecting federal equipment standards for products manufactured between July 1, 2001 and September 15, 2014.

Compact Refrigerator, Refrigerator-Freezer and Freezer[20]

Product Class	ΔkWh/unit
Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost	9.03AV + 252.3
Compact all refrigerators---manual defrost	7.84AV + 219.1
Compact refrigerator-freezers--partial automatic defrost	5.91AV + 335.8
Compact refrigerator-freezers--automatic defrost with top-mounted freezer	11.80AV + 339.2
Compact refrigerator-freezers--automatic defrost with top-mounted freezer with an automatic icemaker	11.80AV + 423.2
Compact all refrigerators---automatic defrost	9.17AV + 259.3
Compact refrigerator-freezers--automatic defrost with side-mounted freezer	6.82AV + 456.9
Compact refrigerator-freezers--automatic defrost with side-mounted freezer with an automatic icemaker	6.82AV + 540.9
Compact refrigerator-freezers--automatic defrost with bottom-mounted freezer	11.80AV + 339.2
Compact refrigerator-freezers--automatic defrost with bottom-mounted freezer with an automatic icemaker	11.80AV + 423.2
Compact upright freezers with manual defrost	8.65AV + 225.7
Compact upright freezers with automatic defrost	10.17AV + 351.9
Compact chest freezers	9.25AV + 136.8

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.96.[21]

Baseline Efficiencies from which Energy Savings are Calculated

The savings calculations above apply to recycling of a functioning primary[22] or secondary refrigerator, refrigerator-freezer, or freezer with total refrigerated volume of 7.75 ft^3 (220 liters) or more or compact refrigerator/refrigerator-freezer/freezer with total refrigerated volume of less than 7.75 ft^3 (220 liters).

[20] 10 CFR, 430.32 (a) Refrigerators/ refrigerator-freezer, freezers, Energy and water conservation standards and their compliance dates.

[21] Derived from Verified Gross Savings values presented in Table 1-1 of Appliance Recycling Program Impact Evaluation study prepared by DNV, June 30th, 2021. Based on the application of PY 2019 VGS kWh of 4,552,840 and VGS kW of 642in the Summer Peak Coincident Demand Savings algorithm above.

[22] Savings can be claimed for recycling a primary refrigerator as long as savings for that replacement were not claimed by another energy efficiency program.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the recycling of an existing 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.

Example Calculation *(Not to be used as default)*

An existing residential customer recycles a primary refrigerator unit. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

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

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

$$\Delta MMBtu = N/A$$

units = 1, from application
(ΔkWh/unit) = 958, from Summary of Variables and Data Sources table
TAF = 1.22, from Summary of Variables and Data Sources table
LSAF = 1.06, from Summary of Variables and Data Sources table
CF = 0.96, from Summary of Variables and Data Sources table

$$\Delta kWh = 1 \times 958 = 958\ kWh$$

$$\Delta kW = 1 \times \left(\frac{958}{8{,}760}\right) \times 1.22 \times 1.06 \times 1.0 = 0.13\ kW$$

$$\Delta MMBtu = 0$$

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
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.
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7-13-4	7/31/2013
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12-17-2	12/31/2017
6-19-4	6/28/2019
12-21-2	1/28/2022
3-23-3	3/31/2023

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BUILDING SHELL

INSULATION – HOT WATER AND STEAM PIPE

Measure Description

This measure covers the installation of fiberglass or rigid foam/cellular glass pipe insulation in space heating hot water/steam and domestic hot water (DHW) distribution systems on uninsulated copper, steel, CPVC or PEX piping with a nominal diameter between 0.50″ and 4.00″. Estimation of energy savings depends on the type and size of the pipe, type and thickness of the insulation, supply temperature of the heating medium and ambient temperature.

This measure is applicable in retrofit applications and must be installed by a qualified contractor complying with all relevant construction and safety codes and standards. All insulation materials installed under this measure are to be tested in accordance with all pertinent federal testing standards (ASTM) and must be rated for the temperature range of the heating medium conveyed by the affected system. Service hot water pipe insulation for non-recirculating systems is limited to insulation of hot water distribution pipe in unconditioned spaces only. Space heating pipe insulation is limited to insulation installed in unheated spaces only.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,elec} \times 3{,}412} \times l \times \Delta T \times hrs \times ElecSF$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{8{,}760} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,fuel} \times 1{,}000{,}000} \times l \times \Delta T \times hrs \times FuelSF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition
(UA/L)	= Overall heat transfer coefficient per unit length (BTU/h-°F-ft)
E_t	= Thermal efficiency of hot water source
l	= Length of installed insulation (ft)

ΔT = Temperature difference between hot water in pipe and surrounding ambient air temperature (°F)
hrs = Annual operating hours
ElecSF = Electric Savings Factor: Adjustment to electric energy savings based on fuel type
FuelSF = Fossil fuel Savings Factor: Adjustment to fossil fuel energy savings based on fuel type
CF = Coincidence factor
3,412 = Conversion factor, one kW equals 3,412 BTU/h
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(UA/L)_{baseline}$		Lookup from Baseline Efficiencies section below, based on pipe diameter, pipe material and application.
$(UA/L)_{ee}$		Lookup from Compliance Efficiency section below, based on pipe diameter and insulation type and thickness.
$E_{t,elec}$	DHW: 0.98	Recovery efficiency of typical electric storage type water heater.[23]
$E_{t,fuel}$	DHW: 0.75 Gas-Fired HW Boiler: 0.84 AFUE Gas-Fired Steam Boiler: 0.82 AFUE Oil-Fired HW Boiler: 0.86 AFUE Oil-Fired Steam Boiler: 0.85 AFUE	Recovery efficiency of typical gas and oil storage type water heater and base-line efficiency of residential-size space heating boilers. [24,25]
l		From application.
ΔT	$T_{pipe} - T_{amb}$	
T_{pipe}	DHW: 125 HW Boiler: 160 Steam Boiler: 212	Average temperature of hot water in distribution system piping (°F). [26]
T_{amb}	DHW: 70 Space Heat: 50	Surrounding average ambient air tem-perature (°F). [27,28]

[23] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*.
[24] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[25] 10 CFR 430.32(e)(iii)(A).
[26] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.
[27] Average annual ambient temperature in unconditioned spaces.
[28] Average ambient temperature based on typical heating season conditions of unconditioned basements.

Variable	Value	Notes
ElecSF	Electric WH: 1.00 Fossil Fuel WH: 0 Unknown WH: 0.31 Space Heat: 0	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[29] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration or delivery mechanism.
FuelSF	Electric WH: 0 Fossil Fuel WH: 1.00 Unknown WH: 0.56 Space Heat: 1.00	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[30] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration or delivery mechanism.
hrs	DHW: 8,760 Space Heat: $EFLH_{heating}$ (Appendix G)	See Operating Hours section below.
CF	DHW: 1.0 Space Heat: N/A	

Coincidence Factor (CF)

The prescribed value for the coincidence factor for domestic water heating is 1.0.[31]
The prescribed value for the coincidence factor for space heating is N/A.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a length of uninsulated copper, steel, CPVC or PEX domestic hot water or space heating piping located in an unconditioned space. Prescribed $(UA/L)_{baseline}$ values are provided in the table below based on the diameter of pipe, pipe material, and application. Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Values were developed using NAIMA's 3E Plus software program.[32] Insulation of HDPE piping is not eligible for savings under this measure.[33]

[29] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7, Fuel used by main water heater ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating).
[30] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7, fuel used by main water heater ("Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating).
[31] *No source specified – update pending availability and review of applicable references.*
[32] Insulation Institute, 3E Plus® Version 4.1.
[33] HDPE piping was found to have limited savings potential through preliminarily modeling in 3E Plus® Version 4.1.

Pipe Diameter (in)	$(UA/L)_{baseline}$						
	Bare Copper Piping			Bare Steel Piping		Bare CPVC/PEX Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat	Domestic Hot Water	Hot Water Heat
0.50	0.44	0.48	0.53	0.53	0.59	0.39	0.41
0.75	0.54	0.58	0.64	0.65	0.72	0.48	0.50
1.00	0.65	0.70	0.78	0.79	0.88	0.56	0.58
1.25	0.80	0.86	0.96	0.97	1.09	0.69	0.72
1.50	0.90	0.97	1.09	1.10	1.23	0.78	0.81
2.00	1.10	1.19	1.33	1.34	1.51	0.95	0.98
2.50	1.31	1.42	1.58	1.60	1.80	1.07	1.11
3.00	1.57	1.70	1.90	1.92	2.16	1.23	1.27
3.50	1.77	1.92	2.15	2.18	2.45	1.38	1.42
4.00	1.98	2.14	2.40	2.43	2.73	1.52	1.57

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a length of copper or steel service hot water or space heating hot water/steam distribution piping insulated in accordance with ECCCNYS[34] which require hot water piping with 0.50" nominal diameter and larger to be insulated with a minimum thermal resistance of R-3. The R-value is the thermal resistance of the insulating material, which is derived by dividing the thickness of the material by the material's thermal conductivity, or k-value. Thermal transmittance, or the material's U-factor, is the inverse of the R-value.

The $(UA/L)_{ee}$ values associated with fiberglass, rigid foam and cellular glass insulation of various thicknesses provided in the table below shall be used to establish the compliance condition heat transfer coefficient. Pipe diameter and insulation type and thickness shall be taken from the application. The values below were calculated using a k-value of 0.25 BTU-in/h-°F-ft^2 for fiberglass and 0.35 BTU-in/ h-°F-ft^2 for rigid foam and cellular glass insulation at 100°F. Pipe wall resistance and exterior film resistance were ignored in the derivation of the values below. Values were developed using NAIMA's 3E Plus software program.[35]

Pipe Diameter (in)	$(UA/L)_{ee}$											
	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1.0 in	1.5 in	2.0 in	2.5 in	3.0 in	0.5 in	1.0 in	1.5 in	2.0 in	2.5 in	3.0 in
0.50	0.12	0.09	0.08	0.07	0.06	0.06	0.16	0.12	0.10	0.09	0.09	0.08
0.75	0.14	0.10	0.09	0.08	0.07	0.07	0.18	0.14	0.12	0.11	0.10	0.09
1.00	0.16	0.12	0.10	0.09	0.08	0.07	0.21	0.16	0.13	0.12	0.11	0.10
1.25	0.19	0.14	0.11	0.10	0.09	0.08	0.24	0.18	0.15	0.13	0.12	0.11
1.50	0.21	0.15	0.12	0.10	0.09	0.09	0.27	0.20	0.16	0.14	0.13	0.12
2.00	0.25	0.17	0.14	0.12	0.11	0.10	0.32	0.23	0.19	0.16	0.15	0.13
2.50	0.29	0.20	0.16	0.13	0.12	0.11	0.37	0.26	0.21	0.18	0.16	0.15
3.00	0.34	0.23	0.18	0.15	0.13	0.12	0.43	0.30	0.24	0.21	0.18	0.17
3.50	0.38	0.26	0.20	0.17	0.15	0.13	0.47	0.33	0.27	0.23	0.20	0.18
4.00	0.42	0.28	0.22	0.18	0.16	0.14	0.52	0.36	0.29	0.25	0.22	0.20

[34] ECCCNYS 2020, R403.5.3.
[35] Insulation Institute, 3E Plus® Version 4.1.

Operating Hours

Domestic hot water heaters are assumed to be available for operation 8,760 hours per year.

Operating hours for water and steam boilers in space heating systems are established on the basis of equivalent full-load hours. Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY by location, building type and vintage are tabulated in Appendix G.

Example Calculation *(Not to be used as default)*

An existing residential customer living near Poughkeepsie installs 0.5" fiberglass pipe insulation on 20 feet of bare copper domestic hot water piping with a 1.00" diameter. The home has electric water heating. Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated below.

$$\Delta kWh = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,elec} \times 3{,}412} \times l \times \Delta T \times hrs \times ElecSF$$

$$\Delta kW = \frac{\Delta kWh}{8{,}760} \times CF$$

$(UA/L)_{baseline}$ = 0.65, from baseline efficiency based on pipe material, size, and application
$(UA/L)_{ee}$ = 0.16, from compliance efficiency based on insulation material, thickness and pipe size
$E_{t,elec}$ = 0.98, from Summary of Variables and Data
$\Delta T = T_{pipe} - T_{amb}$ = 125-70 = 55, from Summary of Variables and Data Sources table based on pipe application
hrs = 8,760, from Operating hours section based on pipe application
l = 20, from application
ElecSF = 1.0, from Summary of Variables and Data Sources table based on application
CF = 1.0, from Summary of Variables and Data Sources table based on application

$$\Delta kWh = \frac{(0.65 - 0.16)}{0.98 \times 3{,}412} \times 20 \times 55 \times 8{,}760 \times 1.0 = 1{,}383.26\ kWh$$

$$\Delta kW = \frac{1{,}383.26}{8{,}760} \times 1.0 = 0.16\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Heating, Ventilation and Air Conditioning (HVAC)

<u>Energy and Heat Recovery Ventilator</u>

Measure Description

This measure covers the installation of Energy Recovery Ventilator (ERV) and Heat Recovery Ventilator (HRV) equipment. ERVs and HRVs reduce heating and cooling loads while maintaining required ventilation rates by facilitating heat transfer between outgoing conditioned air and incoming outdoor air. ERVs and HRVs employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioning system.[36] This measure only applies in cases where ERV/HRV functionality is not required by federal, state, local or municipal codes or standards. For the purposes of this measure, ERVs and HRVs are distinguished as follows:

<u>Energy Recovery Ventilator (ERV)</u>
Transfers both sensible (heat content) and latent (moisture content) heat between supply and exhaust airstreams.

<u>Heat Recovery Ventilator (HRV)</u>
Transfers sensible heat only between supply and exhaust airstreams.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings (for ERVs)

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}\right)$$

$$\Delta kWh_{cooling} = \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times Eff_{ElecCool}}\right) \times hrs_{cooling} \times \frac{min}{60}$$

$$\Delta kWh_{heating} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000 \times Eff_{ElecHeat}} \times F_{ElecHeat}\right) \times hrs_{heating} \times \frac{min}{60}$$

$$\Delta kWh_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times \left(hrs_{heating} + hrs_{cooling}\right)$$

[36] AHRI GUIDELINE V (I-P)-2011 Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems.

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times EER}\right) \times CF + \Delta kW_{fan}$$

$$\Delta kW_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000{,}000 \times Eff_{FuelHeat}} \times F_{FuelHeat} \times hrs_{heating} \times \frac{min}{60}$$

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings (for HRVs)

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}\right)$$

$$\Delta kWh_{cooling} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,cooling} - T_{indoor,cooling}\right)}{1{,}000 \times Eff_{ElecCool}}\right) \times hrs_{cooling} \times \frac{min}{60}$$

$$\Delta kWh_{heating} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000 \times Eff_{ElecHeat}} \times F_{ElecHeat}\right) \times hrs_{heating} \times \frac{min}{60}$$

$$\Delta kWh_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times \left(hrs_{heating} + hrs_{cooling}\right)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,cooling} - T_{indoor,cooling}\right)}{1{,}000 \times EER}\right) \times CF$$

$$\Delta kW_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000{,}000 \times Eff_{FuelHeat}} \times F_{FuelHeat} \times hrs_{heating} \times \frac{min}{60}$$

where:

$$kW_{fan} = \sum \left(\frac{CFM \times \Delta P}{\frac{33{,}013}{5.202} \times Eff_{fan,mech} \times Eff_{fan,motor}} \times 0.746 \right)$$

Or, if any of the above values are unknown (and for baseline supply/exhaust fans):

$$kW_{fan} = \sum \left(\frac{HP \times LF}{Eff_{fan,motor}} \times 0.746 \right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
baseline	= Baseline or Existing condition
ee	= Efficient condition
kW_{fan}	= Total electric power of conventional and ERV/HRV supply and exhaust fans (kW). Sigma operator included to indicate that this term shall include consideration of all supply and exhaust fans in baseline and efficient cases.
heating	= Property of heating season
cooling	= Property of cooling season
CFM	= Volume of supply air in Cubic Feet per Minute
CF	= Coincidence Factor
LF	= Load Factor
$Eff_{hx,total}$	= Total Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[37] or Total Recovery Efficiency rated in accordance with HVI 920[38]
$Eff_{hx,sens}$	= Sensible Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[39] or Sensible Recovery Efficiency rated in accordance with HVI 920[40]
$Eff_{ElecCool}$	= Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER ($\geq$65,000 BTU/h)

[37] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
[38] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge
[39] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
[40] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge

$Eff_{ElecHeat}$	=	Seasonal average energy efficiency of electric heating equipment. Heating Seasonal Performance Factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heating) during the heating season / total electric energy heat pump consumed (in watt-hour); if equipment efficiency is reported in COP, convert to HSPF using the equivalency HSPF = COP x 3.412
EER	=	Energy efficiency ratio under peak conditions (BTU/watt-hour)
$Eff_{FuelHeat}$	=	Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)
$Eff_{fan,mech}$	=	Mechanical efficiency of ERV fans
$Eff_{fan,motor}$	=	Efficiency of ERV fan motors
$F_{ElecHeat}$	=	Electric heating factor, used to account for the presence or absence of an electric heating system
$F_{FuelHeat}$	=	Fossil fuel heating factor, used to account for the presence or absence of a fossil fuel heating system
T_{indoor}	=	Indoor air temperature, in °F
$T_{outdoor}$	=	Outdoor air temperature, in °F
ΔP	=	Supply or exhaust air pressure drop at nominal airflow in the ERV as rated in accordance with AHRI Standard 1060, in inches of water.
$H_{outdoor}$	=	Enthalpy of outside air in BTU/lb
H_{indoor}	=	Enthalpy of inside air at 70°F, in BTU/lb
$hrs_{heating}$	=	Operating hours in the heating season
$hrs_{cooling}$	=	Operating hours in the cooling season
min	=	Run time of ERV/HRV unit in minutes per hour, as configured by the installing contractor
4.5	=	Density of inlet air at 70ºF x 60 min/hr, in lb-min/ft^3-hr
1.08	=	Specific heat of air × density of inlet air @ 70˚F × 60 min/hr[41] in BTU/h-ºF-CFM
1,000,000	=	Conversion factor, one MMBtu equals 1,000,000 BTU
33,013	=	Conversion factor from horsepower to ft.lb/min
5.202	=	Conversion factor from inches of water to pounds per square ft (lb/sq.ft)
0.746	=	Conversion factor (kW/hp), 746 watts equals one electric horsepower
60	=	Minutes in one hour
1,000	=	Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
CFM		From application.
$Eff_{hx,total}$		From application.
$Eff_{hx,sens}$		From application.

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

Variable	Value	Notes
$Eff_{ElecCool}$		From application or use 14 SEER, assuming a 3-ton central ASHP system.[42] For equipment rated in SEER2, SEER2 rating shall be used.
$Eff_{FuelHeat}$		From application, E_c, E_t, or AFUE shall be used, based on nameplate rating metric of existing equipment. If unknown, lookup in tables below based on equipment type and size.
$Eff_{ElecHeat}$		From application or use 8.2 HSPF, assuming a 3-ton central ASHP system.[43] For electric resistance heating and electric furnaces, use 3.4 HSPF. If taken from application, COP must be converted to HSPF using the equivalency HSPF = COP x 3.412. Use HSPF2 if equipment has an HSPF2 rating.
EER		From application. For equipment rated in EER2, EER2 rating shall be used. If unknown, EER is established as follows[44]: $EER = (1.12 \times SEER) - (0.02 \times SEER^2)$
$Eff_{fan,mech}$		From application; if unknown use 0.67.[45]
$Eff_{fan,motor}$		Efficiency of supply and exhaust fan components of the ERV. From application, if unknown use 0.70 based on 1/4hp, 4-pole polyphase motor.[46]
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise use 0.0.
$H_{outdoor}$		Lookup from Climate Data table below based on location.[47]
H_{indoor}		If indoor set temperature is known, lookup from Indoor Enthalpy table below. Otherwise, use 25.3 based on 70°F and 50% RH indoor air conditions.
T_{indoor}		From application or use 70°F.
$T_{outdoor}$		Average of temperatures from the heating and cooling season based on the city. Lookup value from table below.
ΔP		From application.
$hrs_{heating}$		Lookup in the Operating Hours table based on location.
$hrs_{cooling}$		Lookup in the Operating Hours table based on location.
min		From application.[48]

42 10 CFR 430.32 (c)(1).
43 Ibid.
44 DOE, Building America House Simulation Protocols, October 2010; for equipment rated in SEER2, replace SEER with SEER2 and EER with EER2 in the derivation formula.
45 ASHRAE 90.1 2013, Section 6.5.3.1.3.
46 10 CFR 431.446.
47 NCEI 1991-2020 Annual/Seasonal Climate Normals.
48 Review of both ASHRAE Standard 62.2 – 2019 and ASHRAE Research Project 1663 "Best Practices for Home Design, Construction, Operation, and Maintenance" reveal that there is no standard guidance for configuring residential ERV operations. Best practices for determining "Minutes/Hour" depend on many variables related to how the ERV/HRV is installed (as part of bathroom exhaust, integrated into the return ductwork of an air-handler, completely decoupled from the home's HVAC system, etc.). As such, a representative value for "Minutes/Hour" of operation cannot easily be characterized and is inspectable.

Variable	Value	Notes
CF	0.69	
LF		From application. If unknown use 0.92 as default value.[49]

Indoor Enthalpy (H_{indoor})

Temperature (°F)	Relative Humidity	Enthalpy (H_{indoor})
65	50%	22.7
66	50%	23.2
67	50%	23.7
68	50%	24.2
69	50%	24.8
70	50%	25.3
71	50%	25.8
72	50%	26.4
73	50%	27.0
74	50%	27.5
75	50%	28.1
76	50%	28.7
77	50%	29.3
78	50%	29.9

Outdoor Air Temperature & Enthalpy

Look up outdoor air temperature and enthalpy based on the city in the table below. The table below summarizes the average outdoor air temperature and enthalpy during the Heating (<65°F) and Cooling (>65°F) seasons across a typical climatological year.

City	$T_{outdoor,heating}$ (°F)	$T_{outdoor,cooling}$ (°F)	$H_{outdoor,heating}$ (Btu/lb)	$H_{outdoor,cooling}$ (Btu/lb)
Albany	41.89	72.09	11.80	29.57
Binghamton	41.77	70.45	11.30	28.04
Buffalo	42.02	71.36	12.10	28.80
Massena	39.07	71.84	12.10	29.18
NYC	45.90	73.10	14.34	30.86
Poughkeepsie	43.08	73.28	13.78	30.66
Syracuse	41.88	71.95	11.94	29.33

[49] Cascade Energy. "Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors." Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[50]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is a single or multi-family dwelling with an ASHRAE 62.2-compliant exhaust fan system with no heat or energy recovery.

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

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[51]

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

The baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[52] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

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

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.80 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE
	≥ 225 kBTU/h	0.81 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec

[50] 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.
[51] 10 CFR 430.32(e).
[52] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5).

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is a building with an ASHRAE 62.2-compliant exhaust fan system equipped with AHRI 1060 or HVI 920 certified ERV or HRV components.

Operating Hours

Look up hours based on city in the table below. The table below summarizes the sum of heating and cooling hours across a typical climatological year.[53,54]

City	$hrs_{Heating}$	$hrs_{cooling}$
Albany	5,087	1,712
Binghamton	5,088	1,304
Buffalo	5,041	1,725
Massena	5,088	1,315
NYC	5,025	2,093
Poughkeepsie	5,052	1,697
Syracuse	5,088	1,666

[53] Using 65°F as the balance point, the cooling season is defined as when outdoor air temperature is above 65°F for the months of June through August and the heating season is defined as when outdoor air temperature is below 65°F for the months of October through April. Temperature values are based on the average of temperature during the cooling and heating seasons, respectively.
[54] NOAA National Center for Environmental Information – NCEI 1991 – 2020 Annual/Seasonal Climate Normals.

Example Calculation *(Not to be used as default)*

An ERV delivering 200 CFM is installed in a single family home with an existing ¼ hp exhaust fan system of 70% efficiency located near Albany constructed in 1965. The ERV has a sensible effectiveness of 88% and total effectiveness of 68%, and runtime is set at 50%, operating 30 minutes per hour. The building is cooled by a central air conditioner with 13 SEER and heated by an 80% thermal efficient gas furnace, where the indoor cooling temperature is set at 70ºF, and the indoor heating temperature is set at 70ºF. The ERV fan has a motor efficiency of 80%, a mechanical efficiency of 65%, and a pressure drop of 0.4 inches of water. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}\right)$$

$$\Delta kWh_{cooling} = \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times Eff_{ElecCool}}\right) \times hrs_{cooling} \times \frac{min}{60}$$

$$\Delta kWh_{heating} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000 \times Eff_{ElecHeat}} \times F_{ElecHeat}\right) \times hrs_{heating} \times \frac{min}{60}$$

$$\Delta kWh_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times \left(hrs_{heating} + hrs_{cooling}\right)$$

$$\Delta kW = units \times \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,cooling} - T_{indoor,cooling}\right)}{1{,}000 \times EER}\right) \times CF + \Delta kW_{fan}$$

$$\Delta kW_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times CF$$

$$\Delta MMBtu = units \times \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000{,}000 \times Eff_{FuelHeat}} \times F_{FuelHeat} \times hrs_{heating} \times \frac{min}{60}$$

where:

$$kW_{fan} = \sum\left(\frac{CFM \times \Delta P}{\frac{33{,}013}{5.202} \times Eff_{fan,mech} \times Eff_{fan,motor}} \times 0.746\right)$$

Or, if any of the above values are unknown (and for baseline supply/exhaust fans):

$$kW_{fan} = \sum \left(\frac{HP \times LF}{Eff_{fan,motor}} \times 0.746 \right)$$

units = 1, from application
CFM = 200, from application
$Eff_{hx,total}$ = 0.68, from application
$H_{outdoor,cooling}$ = 29.57 BTU/lb, from Outdoor Air Temperature & Enthalpy table based on location from application
$H_{indoor,cooling}$ = 25.3 BTU/lb, from on Indoor Enthalpy table based on indoor temperature from application
$Eff_{ElecCool}$ = 13, from application
EER = (1.12 x 13) – (0.02 x 13^2) = 11.2, from Summary of Variables and Data Sources table
$kW_{fan,ee}$ = (200 x 0.4) / (33,013/5.202 x 0.65 x 0.80) x 0.746 = 0.02
  ΔP = 0.4, from application
  $Eff_{fan,mech}$ = 0.65, from application
  $Eff_{fan,motor}$ = 0.80, from application
$kW_{fan,baseline}$ = (0.25 x 0.92) / .70 x 0.746 = 0.25 kW
  HP = 0.25, from application
  LF = 0.92, from Summary of Variables and Data Sources table
  $Eff_{fan,motor}$ = 0.70, from application
$hrs_{cooling}$ = 1,712, from Operating Hours table based on location from application
min = 30, from application
$Eff_{hx,sens}$ = 0.88, from application
$T_{indoor,heating}$ = 70ºF, from application
$T_{outdoor,heating}$ = 41.89ºF, from Outdoor Air Temperature & Enthalpy table based on location from application
$Eff_{ElecHeat}$ = N/A, from application
$F_{ElecHeat}$ = 0, from application
$hrs_{heating}$ = 5,087, from Operating Hours table based on location from application
CF = 0.69, from Summary of Variables and Data Sources table
$Eff_{FuelHeat}$ = 0.80, from application
$F_{FuelHeat}$ = 1, from application

$$kW_{fan,ee} = \sum \left(\frac{200 \times 0.4}{\frac{33{,}013}{5.202} \times 0.65 \times 0.80} \times 0.746 \right) = 0.02\ kW$$

$$kW_{fan,baseline} = \sum \left(\frac{0.25 \times\ 0.92}{0.70} \times 0.746 \right) = 0.25\ kW$$

$$\Delta kWh_{cooling} = \left(\frac{4.5 \times 200 \times 0.68 \times (29.57 - 25.3)}{1{,}000 \times 13} \right) \times 1{,}712 \times \frac{30}{60} = 172.07\ kWh$$

$$\Delta kWh_{heating} = 0\ kWh$$

$$\Delta kWh_{fan} = (0.25 - 0.02) \times (5{,}673 + 1{,}571) = 1{,}666.12\ kWh$$

$$\Delta kWh = 1 \times (172.07 + 0 + 1{,}666.12) = 1{,}838.19\ kWh$$

$$\Delta kW_{fan} = (0.25 - 0.02) \times 0.69 = 0.16\ kW$$

$$\Delta kW = 1 \times \left(\frac{4.5 \times 200 \times 0.68 \times (29.57 - 25.3)}{1{,}000 \times 11.2}\right) \times 0.69 + 0.157 = 0.32\ kW$$

$$\Delta MMBtu = 1 \times \frac{1.08 \times 200 \times 0.88 \times (70 - 41.89)}{1{,}000{,}000 \times 0.80} \times 1 \times 5{,}087 \times \frac{30}{60} = 16.98\ MMBtu$$

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

Employing ERVs in the winter may exchange latent heat decreasing the need to run a humidifier, but the impact is expected to be negligible and is not quantified in the prescribed estimation methodology for this measure at this time.

References

1. ECCCNYS 2020 Table C403.3.2(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements.
   Available from https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[ce]-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC403
2. 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
3. 10 CFR 431.446 Small electric motors energy conservation standards and their effective dates.
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4. AHRI GUIDELINE V (I-P)-2011 Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems. Available from: http://www.ahrinet.org/App_Content/ahri/files/Guidelines/AHRI_Guideline_V_I-P_2011.pdf
5. AHRI Standard 1060 (I-P), 2018 Standard for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
   Available from: https://www.ahrinet.org/sites/default/files/2022-06/AHRI_Standard_1060_I-P_2018.pdf
6. HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge, February 2020
   Available from: https://hvi.iwrapper.com/HVI_Certification_Program_Policies/Publication_920
7. NOAA National Center for Environmental Information – NCEI 1991 – 2020 Annual/Seasonal Climate Normals.
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
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   Available from: https://rtf.nwcouncil.org/meeting/rtf-meeting-november-14-2012
9. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps.
10. Performance Rating of air-to-air exchanges for Energy Recovery Ventilation Equipment.
   Available from: http://www.ahrinet.org/ERVcertification

Record of Revision

Record of Revision Number	Issue Date
7-20-2	7/31/2020
6-22-5	9/2/2022
3-23-8	3/31/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

HEAT PUMP – AIR SOURCE (CCASHP)

Measure Description

This measure covers the installation of cold climate Air Source Heat Pump (ccASHP) systems[55] with total rated heating capacity less than 300,000 BTU/h that provide heating and cooling in for space conditioning in residential applications.[56] An air source heat pump is a product, other than a packaged terminal heat pump or single package vertical heat pump, which is powered by single phase electricity, air cooled, not contained within the same cabinet as a furnace with rated capacity above 225,000 BTU/h, and operates as a heat pump in both heating and cooling mode. This measure applies to central ducted systems, single zone split-systems with ductless indoor units that may be wall-mounted, floor-mounted, or ceiling-mounted and multi-zone split systems with one outdoor section and multiple indoor sections. These indoor sections may be a combination of ductless or compact ducted units.

This measure is based on several assumptions consistent with best practice design for a quality ASHP installation:

- Residential NYS code and Federal Standard (ECCCNYS 2020, Code of Federal Regulations 10 CFR 430.32) or local legislation applicable at the time of installation should be referenced for correct baseline system and efficiency values.

- Systems shall be sized in accordance with ACCA Manual S based on building design loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.[57,58]

- The building design heating load in New York typically exceeds the design cooling load, therefore it is assumed that the ASHP is sized for the building or zone heat load.

The applicability of this measure for a whole-house application is limited to an ASHP system that is sized and installed to provide between 90% and 120% of the design heating load.[59] For a whole house application scenario, when the system is sized such that supplemental electric resistance heat is included within the heat pump to help meet the design heating load, the efficiency of the resistance heating is assumed to be equal to 1 in this analysis. Smaller system sizes are allowable for heating displacement applications in conformance with the NEEP *Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates*[60].

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[55] NEEP Cold Climate Air Source Heat Pump (ccASHP) Specification (Version 4.0) effective January 1, 2023

[56] "Residential application" means detached one- and two-family dwellings and townhouses not more than three stories above-grade in height with a separate means of egress and their accessory structures, and one-family dwellings converted to bed and breakfast dwellings.

[57] ECCCNYS 2020, Section R403.7.

[58] ECCCNYS 2020 requires that systems serving multiple dwelling units follow Sections C403 and C404.

[59] Code reference above. The 90% minimum does not include supplemental heat. Note that Manual S allows use of *low-speed* cooling capacity to determine the cooling size limit of 115% of design total cooling load.

[60] neep.org/sites/default/files/Sizing & Selecting ASHPs In Cold Climates.pdf

The ASHP efficiency must meet the Northeast Energy Efficiency Partnerships (NEEP) Cold Climate Air Source Heat Pump (ccASHP) Specification (Version 4.0) effective January 1, 2023. The specification uses AHRI-certified performance ratings and manufacturer reported data to describe the efficiency and capacity of the unit under full and part load conditions. This equipment is rated under ANSI/AHRI 210/240.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\begin{aligned}\Delta kWh = \Bigg(&\left(BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{SEER_{baseline}} - \frac{1}{EER_{season,ee}}\right) \times BEFLH_{cooling} \times F_{load,cooling}\right)\\ &+ \left(BHL \times \frac{1}{1{,}000} \times \left(\frac{F_{ElecHeat}}{COP_{season,baseline}} - \frac{1}{COP_{season,ee}}\right) \times \frac{1}{3.412} \times BEFLH_{heating}\right.\\ &\left.\times F_{load,heating} \times F_{ctrl}\right)\\ &- \left(BHL \times \frac{1}{1{,}000} \times F_{ElecHeat,new} \times \frac{1}{3.412} \times BEFLH_{heating} \times \left(1 - F_{load,heating} \times F_{ctrl}\right)\right)\Bigg)\end{aligned}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times F_{load,cooling} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = BHL \times \frac{1}{1{,}000{,}000} \times \frac{F_{FuelHeat}}{AFUE_{baseline}} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
BCL	= Building Cooling Load at design conditions (BTU/h)
BHL	= Building Heating Load at design conditions (BTU/h)
$F_{ElecHeat}$	= Electric heating factor; used to account for the presence or absence of an electric heating system
$F_{ElecHeat,new}$	= New electric heating factor; used to account for a new heat pump’s reliance on supplemental electric resistance heat to meet full heating load
$F_{FuelHeat}$	= Fossil fuel heating factor; used to account for the presence or absence of a fossil fuel heating system
$_{baseline}$	= Characteristic of baseline condition
$_{ee}$	= Characteristic of energy efficient condition
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, used for average U.S. location/region
EER	= Full load energy efficiency ratio (BTU/watt-hour)

EER_{season}	= Seasonally adjusted average energy efficiency (BTU/watt-hour)
COP	= Coefficient of performance for heating, ratio of output energy/input energy
COP_{season}	= Seasonally adjusted average coefficient of performance
AFUE	= Annual fuel utilization efficiency, seasonal efficiency for fossil fuel heating equipment
$BEFLH_{cooling}$	= Cooling equivalent full-load hours based on building design load
$BEFLH_{heating}$	= Heating equivalent full-load hours based on building design load
$F_{load,cooling}$	= Adjustment factor to account for the portion of the seasonal[61] cooling load met by the heat pump
$F_{load,heating}$	= Adjustment factor to account for the portion of the seasonal[62] heating load met by the heat pump
F_{ctrl}	= Factor to modify heating load fraction when optional control features are used.
CF	= Coincidence Factor
3.412	= Conversion factor, one watt-hour equals 3.412 BTU
1,000	= Conversion factor, one kilowatt equals 1,000 watts
1,000,000	= Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
BCL		Building cooling load at design conditions, from application.
BHL		Building heating load at design conditions, from application.
$F_{ElecHeat}$		If the baseline heating system is an electric system, set equal to 1. Otherwise, set equal to 0.
$F_{ElecHeat,new}$		If the efficient case heat pump system relies on newly installed supplemental electric resistance heat capacity to meet the peak load, set equal to 1. Otherwise, set equal to 0.
$F_{FuelHeat}$		If the baseline heating system is a fossil fuel system, set equal to 1. Otherwise, set equal to 0.
$SEER_{baseline}$		Electric cooling seasonal energy efficiency rating of baseline equipment. See Baseline Efficiencies section below for details.
$EER_{baseline}$		Electric cooling full load energy efficiency rating of baseline equipment. See Baseline Efficiencies section below for details.
EER_{ee}		Electric cooling full load energy efficiency rating of efficient equipment. See Compliance Efficiency section below for details.
$EER_{season,ee}$		Seasonally adjusted energy efficiency ratio of the efficient equipment. See Compliance Efficiency section below for details.

[61] Fraction of annual (vs. design) cooling load served by the equipment as shown in the Cooling Load Factor table.
[62] Fraction of annual (vs. design) heating load served by the equipment as shown in the Heating Load Factor table.

Variable	Value	Notes
$COP_{season,baseline}$		Seasonally adjusted Coefficient of Performance of the baseline equipment. The assumed COP of an electric resistance/electric furnace system is 1.0. If the baseline is a conventional ASHP[63], use the baseline calculations below.
$COP_{season,ee}$		Seasonally adjusted Coefficient of Performance of the efficient equipment. See Compliance Efficiency section below for details.
$AFUE_{baseline}$		Seasonal fuel energy efficiency of the baseline equipment. See Baseline Efficiency section below for details.
$BEFLH_{cooling}$		Lookup based on building type, vintage and location from the appropriate table in the Operating Hours section below.
$BEFLH_{heating}$		Lookup based on building type, vintage and location from the appropriate table in the Operating Hours section below.
$F_{load,cooling}$		Lookup based on equipment sizing and control parameters from the Cooling Load Factor table below.
$F_{load,heating}$		Lookup based on equipment sizing and control parameters from the Heating Load Factor table below.
F_{ctrl}		Lookup based on optional control features Control Factor table (equals 1 for default control)
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[64]

Baseline Efficiencies from which Energy Savings are Calculated

The baselines used in this measure are determined by the type of equipment that would have been installed without the influence of the program supporting the installation of this measure. This allows for an analysis that does not depend on a typical 'like-for-like' replacement scenario.

An ASHP system can be considered a normal replacement scenario for electric resistance heating (with or without a central electric cooling system), an ASHP system (that provides space heating and cooling), or a fossil fuel fired heating system (with or without a central electric cooling system). The tables below provide baseline efficiencies for electric cooling and heating and fossil fuel fired heating systems.

[63] In this context, "conventional ASHP" is defined as a minimally code-compliant non-NEEP listed ASHP with efficiency ratings as indicated in the Baseline Efficiencies section below.

[64] 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.

For scenarios where there is new construction or substantial renovation, the baseline is assumed to be a fossil fuel fired warm air furnace of the fuel type most likely to be installed at the project site without the influence of the program with a central air conditioning system.

The baseline efficiency for electric cooling and heating systems is defined by the Code of Federal Regulations as shown in the table below.

Electric Cooling and Heating System Baseline Efficiencies

Product Class	Seasonal Energy Efficiency Ratio (SEER)[65]	Energy Efficiency Ratio (EER)	Heating Seasonal Performance Factor (HSPF)[66]
Split System – Air Conditioner (<45 kBTU/h)	13.0	11.2	N/A
Split System – Air Conditioner (≥45 and <65 kBTU/h)	13.0	11.2	N/A
Single Package – Air Conditioner	14.0	11.8	N/A
Split System – Heat Pump (<45 kBTU/h)	14.0	11.8	8.2
Split System – Heat Pump (≥45 and < 65 kBTU/h)	14.0	11.8	8.2
Single Package – Heat Pump (<65 kBTU/h)	14.0	11.8	8.0

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

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[67]

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

[65] 10 CFR 430.32(c)(1).
[66] 10 CFR 430.32(c)(1).
[67] 10 CFR 430.32(e).

The baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[68] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

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

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6[69]
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.80 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE
	≥ 225 kBTU/h	0.81 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec
Boiler,, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

For scenarios where the baseline heating system is electric resistance heat or an electric furnace, the baseline efficiency is assumed to be a COP of 1.0.

For scenarios where the baseline heating system is a conventional ASHP, additional consideration is given to account for the significant difference between the rating conditions for HSPF and the typical operating conditions in New York State, as shown below.

The HSPF is the AHRI-rated heating seasonal average efficiency expressed in terms of BTU/watt-hour. A seasonally adjusted $COP_{baseline}$ of a conventional air-source heat pump is used in the above equations. This adjusted baseline COP shall be calculated as:

[68] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5).
[69] AFUE: Annual Fuel Utilization Efficiency; Et: Thermal Efficiency; Ec: Combustion Efficiency

$$COP_{season,baseline} = \frac{HSPF \times F_{HSPF}}{3.412}$$

where:

HSPF = Heating seasonal performance factor of the baseline system
F_{HSPF} = HSPF Climate Adjustment Factor, from table below
3.412 = Conversion factor, one watt-hour equals 3.412 BTU

HSPF Climate Adjustment Factor (F_{HSPF}) for Conventional ASHP Used as a Baseline

City	HSPF < 8.5	HSPF ≥ 8.5
Albany	0.70	0.67
Binghamton	0.68	0.65
Buffalo	0.73	0.70
Massena	0.59	0.56
NYC	0.80	0.78
Poughkeepsie	0.62	0.59
Syracuse	0.69	0.66

For scenarios where the baseline cooling system is a conventional ASHP, climate adjustment factors for cooling efficiency are not provided. Differences between SEER rating conditions and typical operating conditions in New York State and cooling load are anticipated to have negligible impact on predicted savings.

Compliance Efficiency from which Incentives are Calculated

ASHPs are rated under ANSI/AHRI 210/240. Cold climate ASHPs must meet the Northeast Energy Efficiency Partnerships (NEEP) Cold Climate Air Source Heat Pump (ccASHP) Specification (Version 4.0) effective January 1, 2023. The specification uses AHRI-certified performance ratings and manufacturer reported data to describe the efficiency and capacity of the unit under full and part load condition.

The average seasonal heating efficiency for an ASHP with a variable speed compressor is calculated as:

$$COP_{season,ee} = a + b \times HSPF \times \frac{1}{3.412}$$

The average seasonal cooling efficiency for a ccASHP with a variable speed compressor is calculated as:

$$EER_{season,ee} = c + d \times SEER$$

where:

a & b = Offset and slope coefficients from Tables below for heating (select based on city and scenario)

c & d = Offset and slope coefficients from Tables below for cooling (select based on city and scenario)
HSPF = Rated Heating Season Performance Factor from AHRI or derived based on guidance in Efficiency Conversion section below
SEER = Rated Seasonal Energy Efficiency Ratio from AHRI or derived based on guidance in Efficiency Conversion section below
3.412 = Conversion factor, one watt-hour equals 3.412 BTU

Note that the cooling efficiency adjustments are quite large for some ASHP units (mini-splits) but much smaller for central ducted ASHP units. For the baseline conventional ASHP we assume that no adjustment to SEER is required. Appendix F in the ASHP White Paper explains why some ASHP units require a cooling efficiency adjustment while others do not.

Summary of Variables and Data Sources

Variable	Value	Source
a & b		Coefficients to represent offset and slope from the table below to determine seasonal heating efficiency ($COP_{season,ee}$) from HSPF. Depends on city and scenario.
c & d		Coefficients to represent offset and slope from the table below to determine seasonal cooling efficiency ($EER_{season,ee}$) from SEER. Depends on city and scenario.
HSPF		Rated heating season performance factor from AHRI or derived based on guidance in Efficiency Conversion section below
SEER		Rated seasonal energy efficiency ratio from AHRI or derived based on guidance in Efficiency Conversion section below

Efficiency Conversion

For equipment with seasonal heating and cooling efficiency ratings in HSPF2 and SEER2 per AHRI, respectively, efficiency ratings shall be converted to HSPF and SEER as follows:

$$HSPF = HSPF2/F_{HSPF2}$$

$$SEER = SEER2/F_{SEER2}$$

Where F_{HSPF2} and F_{SEER2} are established based on equipment type per the table below.[70]

Equipment Type	F_{HSPF2}	F_{SEER2}
Ductless System[71]	0.90	1.00
Centrally Ducted Split System[72]	0.85	0.95

[70] Conversion factors developed by AHRI and adopted by RESNET, as published in Draft PDS-02 MINHERS® Addendum 71f, SEER/HSPF2 Conversions, RESNET, January 2023
[71] Applies to all scenarios labeled 2 and 3 (i.e., 2a – 2h and 3a – 3c) in the Whole Building and Displacement Scenarios table below
[72] Applies to all scenarios labeled 1 and 4 (i.e., 1a – 1d and 4a – 4d) in the Whole Building and Displacement Scenarios table below

Equipment Type	F_{HSPF2}	F_{SEER2}
Centrally Ducted Single Packaged System	0.84	0.95

The scenarios shown in the first column of the Whole Building and Displacement Scenarios table below represent various specific applications of heat pumps, with heat pump type, sizing, and control strategy shown. These scenarios may be considered “sub-measures” of this measure[73]. Assigning applicable scenario(s) to program participants or participant groups is the responsibility of program designers and implementers. For reference, the control strategies listed in the Whole Building and Displacement Scenarios table below are defined as follows:

- **Separate:** The ASHP and backup heating system are on separate thermostats and there is no effort to lock out the heat pump at cold temperatures when the backup system is running.
- **Integrated:** The ASHP and backup heating system are on the same thermostat. The backup heater can modulate (or cycle ON and OFF) to meet the load without limiting the ASHP from delivering its maximum capacity. Also called “Droop” control in the Clean Heat Program.

The Separate and Integrated control options in the table only apply to the Part Load or Displacement scenarios. The impact of optional control features for Whole Building or Full Load are accounted for by the control factor (F_{ctrl}) in the table below. “Single-zone ductless” means the equipment is single-zone (1-to-1 indoor to outdoor units). There may be multiple single-zone systems to achieve the HP sizing shown. When multiple HPs are used, the capacity-weighted rated efficiencies (HSPF, SEER, and EER) for the installed units need to be determined. For both cooling and heating efficiencies, use the rated cooling capacity at 95°F for each unit to find the weighted average for HSPF, SEER and EER.

<u>Whole Building and Displacement Scenarios</u>

Scenario	Description	ASHP Type	Application	Controls	HP Sizing Parameter
1a – 1c	Central ASHP	Central, Ducted	Whole or Full Load	(see F_{ctrl} table)	0.9
1d					1.0
2a	Ductless Mini-Spilt sized at 30%, 50%, 70% and 90/100%	Single-Zone Ductless	Displace or Part Load	Separate	0.3
2b					0.5
2c					0.7
2d				Integrated	0.3
2e					0.5
2f					0.7
2g			Whole or Full Load	(see F_{ctrl} table)	0.9
2h					1.0
3a	Ductless Multi-Split sized to 70% and 90/100%	Multi-Zone Ductless	Displace or Part Load	Separate	0.7
3b			Whole or Full Load	(see F_{ctrl} table)	0.9
3c					1.0

[73] Detailed descriptions of these scenarios and their parameters are found in the white paper *Savings Calculations for Residential Air Source Heat Pumps: The Basis for Modifying EFLH and Seasonal Efficiency Factors for “Whole House” and “Displacement” Applications*, Tables 2 and 3, and the associated narrative.

Scenario	Description	ASHP Type	Application	Controls	HP Sizing Parameter
4a	Compact Ducted Mini-Split sized to 50% ,70% and 90/100%	Single-Zone Compact Ducted	Displace or Part Load	Separate	0.5
4b					0.7
4c			Whole or Full Load	(see F_{ctrl} table)	0.9
4d					1.0

The HP Sizing Parameter should be determined using the maximum heating capacity at 17°F ($QH_{17,max}$) for projects best represented by the New York City climate zone and maximum heating capacity at 5°F from the NEEP Cold Climate Heat Pump List ($QH_{5,max}$) otherwise. BHL is the design heating load for the home:

$$\text{HP Sizing Parameter} = (QH_{17,max} \text{ or } QH_{5,max}) / BHL$$

The HP Sizing Parameter corresponds to the rightmost column in the Whole Building and Displacement Scenarios table above. Choose an appropriate scenario, then use the coefficients from the tables below to determine the seasonal efficiencies and load factors. When the HP Sizing Parameter falls between the values in the column, use the scenario with the lower value.

Note that the HP Sizing Parameter is a factor of convenience for use in this section. It is not necessarily the same as the Actual Sizing Ratio that the participating installers must determine to comply with code and satisfy any requirements established for full load sizing.

$$\text{Actual HP Sizing} = QH\ @\ T_{des} / BHL \quad \neq \quad \text{HP Sizing Parameter}$$

Coefficients for Seasonal Heating Efficiency: $COP_{season,ee} = a + b \times HSPF/3.412$

Scenario	Albany		Binghamton		Buffalo		Massena		New York		Poughkeepsie		Syracuse	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1a 1b 1c	-0.010	0.880	0.113	0.854	0.219	0.842	-0.185	0.838	0.817	0.781	0.333	0.796	0.124	0.860
1d	-0.117	0.902	-0.003	0.879	0.081	0.876	-0.259	0.847	0.876	0.760	0.237	0.815	-0.007	0.890
2a	2.552	0.197	2.532	0.202	2.645	0.181	2.304	0.204	2.631	0.255	2.620	0.177	2.565	0.195
2b	2.351	0.256	2.419	0.243	2.644	0.188	2.011	0.290	2.401	0.329	2.470	0.228	2.500	0.217
2c	2.441	0.228	2.480	0.224	2.619	0.198	2.358	0.203	2.366	0.342	2.459	0.239	2.550	0.206
2d	2.615	0.113	2.637	0.113	2.702	0.108	2.312	0.150	3.002	0.105	2.725	0.104	2.655	0.107
2e	2.574	0.125	2.601	0.124	2.647	0.122	2.335	0.143	2.946	0.122	2.654	0.119	2.631	0.116
2f	2.458	0.160	2.493	0.155	2.546	0.153	2.322	0.145	2.888	0.141	2.588	0.135	2.513	0.154
2g	2.351	0.172	2.382	0.169	2.440	0.161	2.125	0.178	2.836	0.134	2.424	0.162	2.415	0.163
2h	2.336	0.179	2.386	0.169	2.422	0.168	2.030	0.205	2.814	0.146	2.372	0.177	2.414	0.168
3a	-3.334	1.993	-3.307	1.991	-3.485	2.065	-2.938	1.810	-3.593	2.178	-3.093	1.929	-3.339	2.006
3b	-2.683	1.735	-2.637	1.728	-2.720	1.770	-2.004	1.446	-2.914	1.913	-2.306	1.624	-2.710	1.757
3c	-2.823	1.775	-2.783	1.769	-2.832	1.800	-1.991	1.436	-3.094	1.966	-2.395	1.645	-2.861	1.800
4a	-0.333	1.141	-0.305	1.138	-0.251	1.137	-0.852	1.263	0.282	1.070	-0.407	1.194	-0.308	1.140
4b	-0.402	1.155	-0.393	1.160	-0.300	1.147	-0.865	1.261	0.316	1.041	-0.390	1.175	-0.385	1.160
4c	-0.166	1.004	-0.019	0.963	0.018	0.961	-0.234	0.972	0.432	0.924	0.121	0.926	-0.006	0.962
4d	-0.240	1.024	-0.102	0.983	0.027	0.950	-0.321	0.993	0.369	0.940	0.110	0.920	-0.127	1.001

Note that the values for scenarios 1a, 1b and 1c are all the same because of revisions to the controls definitions.

Coefficients for Seasonal Cooling Efficiency: $EER_{season,ee} = c + d \times SEER$

Scenario	Albany		Binghamton		Buffalo		Massena		New York		Poughkeepsie		Syracuse	
	c	d	c	d	c	d	c	d	c	d	c	d	c	d
1a 1b 1c	-0.540	0.961	0.920	0.914	-1.370	1.035	-0.390	0.936	2.910	0.786	-0.510	0.965	-0.810	0.988
1d	-0.460	0.946	-0.140	0.966	-1.670	1.041	-0.210	0.916	1.520	0.859	-0.590	0.961	-0.890	0.982

Coefficients for Seasonal Cooling Efficiency: $EER_{season,ee} = c + d \times SEER$

Scenario	Albany		Binghamton		Buffalo		Massena		New York		Poughkeepsie		Syracuse	
2a	12.330	0.118	11.950	0.116	12.240	0.130	12.360	0.135	11.070	0.165	12.100	0.111	12.180	0.123
2b	11.440	0.208	12.210	0.146	11.010	0.229	10.330	0.273	10.080	0.277	12.130	0.167	11.330	0.210
2c	9.810	0.306	10.940	0.232	9.590	0.302	9.160	0.321	9.440	0.323	10.310	0.282	9.740	0.308
2d	12.330	0.118	11.950	0.116	12.240	0.130	12.360	0.135	11.070	0.165	12.100	0.111	12.180	0.123
2e	11.440	0.208	12.210	0.146	11.010	0.229	10.330	0.273	10.080	0.277	12.130	0.167	11.330	0.210
2f	9.810	0.306	10.940	0.232	9.590	0.302	9.160	0.321	9.440	0.323	10.310	0.282	9.740	0.308
2g	9.400	0.314	9.950	0.300	8.130	0.366	8.500	0.351	8.670	0.353	9.080	0.328	9.080	0.327
2h	8.890	0.336	9.440	0.313	7.960	0.375	8.160	0.364	8.510	0.361	9.130	0.327	9.020	0.332
3a	17.760	-0.189	6.680	0.454	10.960	0.199	18.580	-0.218	11.600	0.196	16.240	-0.105	14.460	-0.008
3b	14.530	0.035	14.100	0.009	15.660	-0.060	11.420	0.204	16.950	-0.122	18.500	-0.205	17.260	-0.147
3c	10.850	0.255	17.070	-0.164	14.630	0.017	13.740	0.066	18.850	-0.246	15.270	-0.009	14.140	0.052
4a	-12.940	1.478	-12.220	1.433	-11.550	1.396	-13.560	1.520	-9.590	1.290	-12.690	1.456	-12.770	1.473
4b	-14.160	1.556	-13.060	1.493	-3.400	0.957	-14.370	1.569	-11.850	1.424	-14.010	1.547	-4.690	1.038
4c	-14.370	1.566	-4.310	1.019	-9.600	1.300	-14.650	1.576	-14.290	1.563	-14.680	1.586	-8.450	1.246
4d	-14.440	1.566	-4.690	1.041	-10.170	1.328	-14.700	1.572	-15.140	1.609	-14.790	1.590	-16.480	1.676

Note that several scenarios are the same since control approach and UR do not apply for cooling (i.e. 1a,1b and 1c are all the same, 2a is the same as 2d, etc.)

Heating Load Factor

Factors in the table below ($F_{load,heating}$) are used to determine the fraction of the annual heating load that is met by the ASHP unit.

Fraction of Heating Load Met by the ASHP ($F_{load,heating}$)

Scenario	Albany	Binghamton	Buffalo	Massena	New York	Poughkeepsie	Syracuse
1a							
1b	1.00	1.00	1.00	0.98	0.99	0.97	1.00
1c							
1d	1.00	1.00	1.00	0.99	1.00	0.98	1.00
2a	0.25	0.25	0.25	0.23	0.24	0.25	0.24
2b	0.39	0.38	0.39	0.37	0.39	0.39	0.38
2c	0.56	0.55	0.56	0.55	0.54	0.54	0.55
2d	0.54	0.53	0.53	0.51	0.54	0.51	0.54
2e	0.74	0.73	0.73	0.71	0.72	0.69	0.74
2f	0.86	0.85	0.85	0.82	0.84	0.81	0.86
2g	0.98	0.97	0.97	0.94	0.97	0.92	0.98
2h	0.99	0.98	0.99	0.95	0.98	0.94	0.99
3a	0.72	0.71	0.70	0.67	0.70	0.67	0.72
3b	0.96	0.94	0.94	0.92	0.95	0.90	0.95
3c	0.97	0.96	0.96	0.94	0.97	0.92	0.98
4a	0.43	0.42	0.43	0.42	0.43	0.43	0.42
4b	0.59	0.58	0.58	0.56	0.55	0.56	0.58
4c	0.97	0.96	0.97	0.94	0.96	0.92	0.98
4d	0.99	0.99	0.99	0.96	0.98	0.95	0.99

Note that the values for scenarios 1a, 1b and 1c are all the same because of revisions to the controls definitions.

Cooling Load Factor

Factors in the table below ($F_{load,cooling}$) are used to determine the fraction of the annual cooling load that is met by the ASHP unit. The cooling sizing is determined using assumptions about the relative size of cooling loads (BCL) and heating loads (BHL) in NY based on climate.

Fraction of Cooling Load Met by the ASHP ($F_{load,cooling}$)							
Scenario	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**New York**	**Poughkeepsie**	**Syracuse**
1a 1b 1c	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1d	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2a	0.90	0.79	0.90	0.95	0.91	0.88	0.89
2b	0.99	0.95	0.99	1.00	0.99	0.99	0.99
2c	1.00	0.99	1.00	1.00	1.00	1.00	1.00
2d	0.90	0.79	0.90	0.95	0.91	0.88	0.89
2e	0.99	0.95	0.99	1.00	0.99	0.99	0.99
2f	1.00	0.99	1.00	1.00	1.00	1.00	1.00
2g	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2h	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3a	1.00	0.99	1.00	1.00	1.00	1.00	1.00
3b	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3c	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4a	0.99	0.96	0.99	1.00	0.98	0.99	0.99
4b	1.00	0.99	1.00	1.00	1.00	1.00	1.00
4c	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4d	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note that several scenarios are the same since control approach and UR do not apply for cooling (i.e. 1a,1b and 1c are all the same, 2a is the same as 2d, etc.)

Optional Control Features

All the whole building or full load scenarios in the Whole Building and Displacement Scenarios table above correspond to separate control or default control of the ASHP systems. If the ASHP has optional control features, the control factors (F_{ctrl}) in the table below shall be used (otherwise F_{ctrl} is equal to 1.0 by default for separate control). The control factors increase (or decrease) the heating load met by the heat pump. Integrated control (droop control) brings on the backup heating source but still allows the heat pump to operate with the backup heat. This corresponds to a standard 2-stage thermostat and is the default control for Centrally Ducted systems (so F_{ctrl} = 1.0). Changeover controls switch from the heat pump to the backup heating source when the temperature is below the changeover threshold (design temperature plus 5°F, or T_{des}+5°F). This changeover temperature equates to 20°F in NYC and 3°F in Albany. Changeover controls are typical for dual-fuel central-ducted systems but are also found in other heat pump controls. With changeover control, the control factor is less than 1, indicating that the heating load and savings are reduced.

Control Factors (Fctrl) for Optional Control Features (Fctrl = 1.0 for default controls)

Whole or Full Load Scenarios	**HP Sizing Parameter**	**NYC**		**Other Cities**	
		Integrated Control	**Changeover T_{des}+5°F**	**Integrated Control**	**Changeover T_{des}+5°F**
Centrally Ducted (Scenarios 1a and 1d)	0.9 1.0	1.00 1.00	0.94 0.93	1.00 1.00	0.99 0.99
Ductless Mini-Spilt (Scenarios 2g and 2h)	0.9 1.0	1.03 1.02	0.96 0.96	1.02 1.01	0.98 0.99
Ductless Multi-Splits (Scenarios 3b and 3c)	0.9 1.0	1.05 1.04	0.93 0.95	1.05 1.03	0.94 0.97
Compact Ducted Scenarios 4c and 4d)	0.9 1.0	1.04 1.02	0.99 0.94	1.03 1.01	0.97 0.97

Operating Hours

The Building Equivalent Full Load Hours for heating ($BEFLH_{heating}$) and for cooling ($BEFLH_{cooling}$) in the tables below represent equivalent full load operating hours for HVAC equipment based on 1% design temperature, TMY3 weather data, and the design heating load. For heating, hours from the summer period (June through September) were excluded. For Cooling, the values of EFLH from Appendix G were multiplied by a factor of 1.25 to convert to BEFLH. All values have been adjusted to reflect 30-year NCEI climate normal from 1991 – 2020.

Single-Family Detached Cooling $BEFLH_{cooling}$ by Vintage and City

City	Old	Average	New
Albany	465	448	403
Binghamton	254	251	202
Buffalo	508	490	419
Massena	353	342	287
NYC	778	752	731
Poughkeepsie	758	718	709
Syracuse	431	411	373

Multi-Family Low-Rise Cooling $BEFLH_{cooling}$ by Vintage and City

City	Prior to 1979	From 1979 Through 2006	From 2007 Through Present
Albany	413	426	403
Binghamton	277	280	269
Buffalo	411	417	389
Massena	314	311	298
NYC	588	638	652
Poughkeepsie	606	646	643
Syracuse	368	395	413

Single-Family Detached Heating $BEFLH_{heating}$ by Vintage and City

City	Old	Average	New
Albany	1,791	1,681	1,567
Binghamton	2,072	1,947	1,815
Buffalo	2,016	1,892	1,763
Massena	1,957	1,852	1,746
NYC	1,595	1,448	1,296
Poughkeepsie	2,047	1,915	1,778
Syracuse	1,938	1,821	1,701

Multi-Family Low-Rise Heating $BEFLH_{heating}$ by Vintage and City

City	Pre-war uninsulated brick	Prior to 1979	From 1979 Through 2006	From 2007 Through present
Albany	1,802	1,670	1,640	1,182
Binghamton	2,389	2,257	2,130	1,537
Buffalo	2,111	2,008	2,002	1,455
Massena	2,400	2,187	2,221	1,615
NYC	1,656	1,255	1,199	834
Poughkeepsie	1,459	1,522	1,478	1,048
Syracuse	2,345	1,976	2,027	1,421

Example Calculation *(Not to be used as default)*

A central ducted air source heat pump is installed in a single-family, detached home located near Albany constructed in 1965. The heat pump is rated at 20 SEER, 13 EER, and 12 HSPF with a total system heating capacity at 5ºF of 60 kBTU/h. The heat pump fully replaces the existing 3-ton central air conditioner and 80 kBTU/h gas fired furnace. The building cooling load is 36 kBTU/h and building heating load is 58 kBTU/h. The system includes supplemental electric resistance heat. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = \Bigg(\bigg(BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{SEER_{baseline}} - \frac{1}{EER_{season,ee}}\right) \times BEFLH_{cooling} \times F_{load,cooling}\bigg) + \bigg(BHL \times \frac{1}{1{,}000} \times \left(\frac{F_{ElecHeat}}{COP_{season,baseline}} - \frac{1}{COP_{season,ee}}\right) \times \frac{1}{3.412} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}\bigg) - \bigg(BHL \times \frac{1}{1{,}000} \times F_{ElecHeat,new} \times \frac{1}{3.412} \times BEFLH_{heating} \times \left(1 - F_{load,heating} \times F_{ctrl}\right)\bigg)\Bigg)$$

$$\Delta kW = BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{\ ee}}\right) \times F_{load,cooling} \times CF$$

$$\Delta MMBtu = BHL \times \frac{1}{1{,}000{,}000} \times \frac{F_{FuelHeat}}{AFUE_{baseline}} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}$$

BCL = 36,000, from application

$SEER_{baseline}$ = 14.0, from Electric Cooling and Heating System Baseline Efficiencies table based on equipment type from application

$EER_{season,ee}$ = c + d x SEER = -0.460 + 0.946 x 20 = 18.46

$EER_{season,ee}$ equation from Compliance Efficiency section

c and d from Coefficients for Seasonal Cooling Efficiency table based on scenario and location from application. To determine scenario, the HP Sizing Parameter is calculated: $QH_{5,max}$ / BHL= 60/58 = 1.03. Thus c and d correspond to scenario 1d based on application conditions

SEER from application

$BEFLH_{cooling}$ = 465, from Operating Hours section tables based on housing type, city, and vintage from application

$F_{load,cooling}$ = 1, from Cooling Load Factor table based on scenario from application

BHL = 58,000, from application

$F_{ElecHeat}$ = 0, from application

$COP_{season,baseline}$ = N/A, from application

$COP_{season,ee}$ = a + b x HSPF x 1/3.412 = -0.117 + 0.902 x 12 x 1/3.412 = 3.14

$COP_{season,ee}$ equation from Compliance Efficiency section

a and b from Coefficients for Seasonal Heating Efficiency table based on scenario and location from application

HSPF from application

$BEFLH_{heating}$ = 1,791, from Operating Hours section tables based on housing type, city, and vintage from application
$F_{load,heating}$ = 1, from Heating Load Factor table based on scenario from application
F_{ctrl} = 1.0 from application for default controls
$F_{ElecHeat,new}$ =1, from application
$EER_{baseline}$ = 11.8, from Electric Cooling and Heating System Baseline Efficiencies table based on equipment type from application
EER_{ee} = 13, from application
CF = 0.69, from Coincidence Factor section
$F_{FuelHeat}$ = 1, from application
$AFUE_{baseline}$ = 0.80, from Baseline Efficiencies section based on equipment type and size from application

$$\begin{aligned}\Delta kWh = \Bigg(&\left(36{,}000 \times \frac{1}{1{,}000} \times \left(\frac{1}{14} - \frac{1}{18.46}\right) \times 465 \times 1\right) \\ &+ \left(58{,}000 \times \frac{1}{1{,}000} \times \left(0 - \frac{1}{3.14}\right) \times \frac{1}{3.412} \times 1{,}791 \times 1 \times 1.0\right) \\ &- \left(58{,}000 \times \frac{1}{1{,}000} \times 1 \times \frac{1}{3.412} \times 1{,}791 \times (1 - 1 \times 1.0)\right)\Bigg) \\ &= -9{,}406.94\ kWh\end{aligned}$$

$$\Delta kW = 36{,}000 \times \frac{1}{1{,}000} \times \left(\frac{1}{11.8} - \frac{1}{13}\right) \times 1 \times 0.69 = 0.19\ kW$$

$$\Delta MMBtu = 58{,}000 \times \frac{1}{1{,}000{,}000} \times \frac{1}{0.80} \times 1{,}791 \times 1 \times 1.0 = 129.85\ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
12-17-8	12/31/2017
9-18-4	9/28/2018
2-20-2	2/28/2020
7-20-21	7/31/2020
3-23-9	3/31/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTAT - WI-FI (COMMUNICATING)

Measure Description

This section covers Wi-Fi communicating thermostats without behavioral learning capability applied to single-family and multi-family residential air conditioners, heat pumps, boilers, furnaces and electric resistance baseboard heating systems. These communicating thermostats allow set point adjustment via a remote application. To claim cooling savings, HVAC systems must have an air conditioner component or be a heat pump system.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings[74]

$$\Delta kWh = units \times \left\{(\Delta kWh/unit)_{cooling} + \left[(\Delta MMBtu/unit) \times \frac{Eff_{FuelHeat}}{COP} \times \frac{1{,}000{,}000}{3{,}412} \times F_{ElecHeat}\right]\right\}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(\Delta kWh/unit)_{cooling}}{EFLH_{cooling}} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times (\Delta MMBtu/unit) \times F_{FuelHeat}$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
$(\Delta kWh/unit)_{cooling}$	= Annual electric cooling savings per unit
(ΔMMBtu/unit)	= Annual heating energy savings per unit
$Eff_{FuelHeat}$	= Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$F_{ElecHeat}$	= Electric heating factor; used to account for the presence or absence of an electric heating system

[74] The $Eff_{FuelHeat}$ and 1,000,000 terms in the equation below are included to convert the evaluated heating savings, which were reported in gas MMBtus, to electric heating savings in kWh for electrically heated buildings. Note that the component of the algorithm containing these terms evaluates to zero for non-electrically heated buildings due to the inclusion of the $F_{ElecHeat}$ term.

$F_{FuelHeat}$	= Fossil fuel heating factor; used to account for the presence or absence of a fossil fuel heating system
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor
3,412	= Conversion factor, one kWh equals 3,412 BTU
1,000,000	= Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(\Delta kWh/unit)_{cooling}$	104	Annual electric cooling savings per installed thermostat, in kWh.[75]
$(\Delta MMBtu/unit)$	6.6	Annual heating energy savings per installed thermostat, in MMBtu.[76]
$Eff_{FuelHeat}$	0.8	From application. If unknown, use 0.8 based on the assumed presence of code compliant natural gas furnaces in the sites assessed in the Cadmus study.[77]
COP	Heat Pump: 2.4 Electric Resistance: 1.0	Assumed efficiency of electric heating system, based on a COP of 1.0 for electric resistance heating and a minimally code compliant, 3-ton split system HP for heat pumps.[78]
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise, use 0.0.
$EFLH_{cooling}$		Lookup based on building type, vintage and location from Appendix G.
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[79]

Baseline Efficiencies from which Energy Savings are Calculated

[75] Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012, pg. 18.
[76] Ibid. pg. 12.
[77] ECCCNYS 2020, Table C403.3.2(4) and Table C403.3.2(5) and Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012.
[78] ECCCNYS 2020, Table C403.3.2(2).
[79] 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.

The baseline efficiency is an HVAC system using fossil fuel and electricity to provide space heating and cooling controlled by a non-Wi-Fi communicating programmable thermostat.

Compliance Efficiency from which Incentives are Calculated

The compliance efficiency is an HVAC system using fossil fuel and electricity to provide space heating and cooling controlled by a Wi-Fi communicating thermostat without behavioral learning capability.

Operating Hours

HVAC system operating hours are embedded in the deemed savings values associated with Wi-Fi communicating thermostats, which are based on metering results. Cooling EFLH data by location, building type and vintage are tabulated in Appendix G.

Example Calculation *(Not to be used as default)*

A Wi-Fi thermostat is installed in single-family detached home located near Albany constructed in 1995. The home is equipped with a heat pump for heating and cooling. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times \left\{ (\Delta kWh/unit)_{cooling} + \left[(\Delta MMBtu/unit) \times \frac{Eff_{FuelHeat}}{COP} \times \frac{1{,}000{,}000}{3{,}412} \times F_{ElecHeat} \right] \right\}$$

$$\Delta kW = units \times \frac{(\Delta kWh/unit)_{cooling}}{EFLH_{cooling}} \times CF$$

$$\Delta MMBtu = units \times (\Delta MMBtu/unit) \times F_{FuelHeat}$$

units = 1, from application
$(\Delta kWh/unit)_{cooling}$ = 104, from Summary of Variables and Data Sources table
$(\Delta MMBtu/unit)$ = 6.6, from Summary of Variables and Data Sources table
$Eff_{FuelHeat}$ = 0.8, from Summary of Variables and Data Sources table
COP = 2.4, from Summary of Variables and Data Sources table based on application equipment
$F_{ElecHeat}$ = 1, from Summary of Variables and Data Sources table based on application
$EFLH_{cooling}$ = 310, from Appendix G based on housing type, building vintage, and location from application.
CF = 0.69, from Summary of Variables and Data Sources table
$F_{FuelHeat}$ = 0, from Summary of Variables and Data Sources table based on application

$$\Delta kWh = 1 \times \left\{ 104 + \left[6.6 \times \frac{0.8}{2.4} \times \frac{1{,}000{,}000}{3{,}412} \times 1 \right] \right\} = 748.78\ kWh$$

$$\Delta kW = 1 \times \frac{104}{310} \times 0.69 = 0.23\ kW$$

$$\Delta MMBtu = 1 \times 6.6 \times 0 = 0\ MMBtu$$

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

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Record of Revision

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1-16-19	12/31/2015
9-17-1	9/30/2017
7-20-3	7/31/2020
3-23-10	3/31/2023

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LIGHTING

INTERIOR AND EXTERIOR LIGHTING

Measure Description

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

Beginning January 2012 and phased in through January 2014, the Energy Independence and Security Act of 2007 (EISA) regulations stipulated typical screw-based general service lamps (GSLs) with wattages ranging from 40W to 100W to comply with new lamp wattage standards such that the range of wattages decreased to be from 29W to 72W for rated lumen output ranging from 310 to 2,600 lumens.[80, 81] A backstop provision was included in this legislation that would require general service lamps to meet a minimum efficacy of 45 lumens per watt beginning on 1/1/2020 in the absence of a final rule amending GSL standards.[82] Additionally in 2017, final rulings were promulgated expanding GSL and GSIL definitions to eliminate exceptions for certain specialty lamps, reflector lamps and decorative lamps effective 1/1/2020.[83,84] The backstop provision and revised definitions rulings were withdrawn prior to their effectuation date and subsequently reinstated by DOE with phased enforcement between January 2023 and July 2023.[85,86] As such, baseline values for market rate applications of this measure shall apply wattages in accordance with revised GSL and GSIL definitions and the imposed 45 lumen per watt standard established via these rulings. Where existing conditions are available, LMI applications of the primary method prescribed below shall establish baseline wattage aligned with existing conditions.

This measure consists of two methods for estimating energy and demand savings. The primary method represented by the first set of algorithms below is suitable for both market rate and LMI applications. The alternative methodology represented by the second set of algorithms shall be used for LMI applications only. This simplified approach relies on average sampling data to establish wattage and consumption reductions and assumed hours of operation. It is only applicable for LMI projects consisting of 16 LED lamps or fewer. Projects exceeding this limit require a lighting schedule.

[80] The maximum rated wattage varies for modified spectrum lamps.
[81] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 86.
[82] 42 U.S.C. 6295(i)(6)(A)(v).
[83] DOE 82 FR 7276.
[84] DOE 82 FR 7322.
[85] DOE 87 FR 27439.
[86] DOE 87 FR 27461.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Fossil Fuel Energy Savings

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

Alternate Method for Calculating Annual Energy Savings for LMI Projects[87]

This methodology for claiming savings is an alternate method that is being tested for future use and will be evaluated for use in both Market-Rate and LMI households.

General Purpose LEDs

$$\Delta kWh = units \times \left(\frac{\Delta W_{LMI,GP} \times 365}{1{,}000}\right) \times hrs$$

Candelabra LEDs[88]

$$\Delta kWh = units \times \Delta kWh_{LMI,Candelbra}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
baseline	= Characteristic of baseline condition
ee	= Characteristic of energy efficient condition

[87] The average wattage reduction per lamp is taken to be 46 watts for A-lamps and 33 watts for candelabra type lamps. The first lamp operating hours for A-lamps prescribed in the Operating Hours section below were determined from the same study used to derive the standard method operating hours. The additional lower hours for larger quantities of A-lamp LEDs are from various sources.

[88] It is assumed that the ΔkWh per Candelabra lamp is 42.2 kWh. This is derived from an assumed ΔW of 33W per lamp and 3.5 hours of usage per day. The savings associated with candelabra lamps is derived from a baseline lamp wattage that is pre-EISA 2020 adjustments. The 2007 baseline maximum for candelabra lamps in EISA states that the wattage cannot exceed 60 watts.

W	= Rated wattage of lamp and/or fixture (Watts)
hrs	= Lighting operating hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
HVACff	= HVAC interaction factor for annual fossil fuel consumption (MMBtu/kWh)
CF	= Coincidence factor
$\Delta W_{LMI,GP}$	= Wattage reduction per general-purpose lamp (LMI only)
$\Delta kWh_{LMI,Candelabra}$	= Annual electric energy savings per candelabra lamp (LMI only)
1,000	= Conversion factor, one kW equals 1,000 Watts
365	= Days per year

Summary of Variables and Data Sources

Variable	Value	Notes
$W_{baseline}$		Baseline measure watts, from appropriate "Baseline Efficiencies" section below. If applying the primary method in an LMI application, in situ wattage may be used in place of assumed baseline wattage.
W_{ee}		Energy efficient measure watts, from application
hrs		Look up in Operating Hours section below based on project type, installation type and location. "Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. "Unknown" is not a valid selection for direct install programs. LMI projects may claim up to 16 LED lamps before requiring a lighting schedule.
$HVAC_c$	Exterior and Unconditioned Spaces: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$	Exterior and Unconditioned Space: 0	HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_{ff}$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual fossil fuel energy consumption (MMBtu/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	Interior: 0.16 Exterior: 0	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting.

Variable	Value	Notes
$\Delta W_{LMI,GP}$	46	Wattage reduction per general-purpose lamp.[89]
$\Delta kWh_{LMI,Candelabra}$	42.2	This is derived from an assumed ΔW of 33W per lamp and 3.5 hours of usage per day.

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

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor for interior lighting is 0.16.[90] This value shall also be used if the installation location is unknown.

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

Baseline Efficiencies from which Energy Savings are Calculated

NOTE: For the purposes of establishing baseline efficiencies for this measure, "Downstream" encompasses any program delivery mechanism that allows for the determination of housing type (Market Rate vs. LMI) and, in the case of LMI programs, existing lamp wattage. "Midstream/Upstream" baselines are intended for program delivery mechanisms where housing type cannot be identified or for LMI programs where existing lamp wattage cannot be identified.

Downstream Market Rate Applications for General Service Lamps

In accordance with DOE final rules published in May 2022, baseline wattage for General Service Lamps (GSLs) (as defined in DOE 87 FR 27461) [91] in market rate applications shall be established

[89] A sampling of recorded pre- and post- wattage of 100 completed EmPower projects, Data reported by a New York City agency (AEA), Inspections completed by Nexant, during a program evaluation ("M&V Evaluation EmPower New York[SM] Program," March 2007)., EmPCalc Honeywell Narrative 10_04_16 10 AM.

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

[91] DOE 87 FR 27461.

based on a minimum standard efficacy of 45 lumens per watt.[92] Baseline wattage shall be derived as follows:

$$W_{baseline} = \frac{Lumens_{ee}}{45}$$

where:

$W_{baseline}$ = Baseline lamp wattage
$Lumens_{ee}$ = Rated light output of efficient lamp
45 = Minimum lumens per watt standard established by DOE final rule

Downstream Market Rate Applications for Exempt Lamps

A general service lamp, as defined in the Code of Federal Regulations, is a lamp, including but not limited to general service incandescent lamps, compact fluorescent lamps, general service light-emitting diode lamps, and general service organic light emitting diode lamps used in general lighting applications that:

(1) Has an ANSI base;
(2) Is able to operate at a voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps, or is able to operate at any voltage for non-integrated lamps;
(3) Has an initial lumen output of greater than or equal to 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens;
(4) Is capable of being operated at voltage range at least partially within 110 and 130 volts.

Certain lamp types were exempt from the original EISA legislation and subsequent final rule amending the definition of GSLs, though several exemptions were discontinued in the latter. For a complete list and definitions of exempt lamp types, as well as discussion of discontinued and maintained exemptions, reference final rules 82 FR 7276 and 82 FR 7322. [93,94]

For products that are not governed by the 45 lumen per watt standard (i.e., do not meet the definition of general service lamp or fall under an exempt product category), the baseline wattage shall be established per ENERGY STAR Watts Equivalent guidance or manufacturer recommended baseline wattage.

Midstream/Upstream Applications for General Service Lamps

Due to lack of availability of customer and existing conditions data in midstream and upstream program delivery mechanisms and the blend of market rate and LMI customer participation in these programs, distinct baseline guidance for these program types that endeavors to account for the proportion of LMI participants across NY state has been developed. The intent of this guidance is a blended baseline applying a 45 lumen per watt standard for market rate participants and an approximated existing condition baseline across the LMI participant population. For the purposes

[92] DOE 87 FR 27439.
[93] DOE 82 FR 7276.
[94] DOE 82 FR 7322.

of this exercise, the approximated existing condition baseline for LMI customers was assumed to align with baselines established for residential lighting prior to the effectuation of the 45 lumen per watt backstop.

Evaluation of 2021 retail LED bulb sales suggest that approximately 37% of residential LEDs are purchased by LMI customers.[95] As such, the baselines prescribed for midstream and upstream applications in the tables below apply a weighting reflecting 37% LMI and 63% market rate participation.

The baselines established below are applicable to midstream and upstream programs as well as downstream LMI programs where the primary calculation methodology above is utilized and existing lamp wattage cannot be collected. For lamps that are not covered by the tables below, either based on bulb type or lumen output, the manufacturer recommended baseline wattage should be used.

Standard Lamps

Bulb Type (a)	**Lumen Range (b)**	**$W_{baseline}$ (c)**
A-Lamp (A15, A17, A19, A21)	< 310	Use ENERGY STAR Watts Equivalent
	310 – 749	22
	750 – 1,049	35
	1,050 – 1,489	46
	1,490 – 2,600	66
	> 2,600	Use ENERGY STAR Watts Equivalent

[95] Cadmus & Demand Side Analytics, "Residential Retail Lighitng Impact Evaluation Final Report", Prepared for Central Hudson, April 20, 2022 – Slide 33.

Specialty Lamps

Baseline wattage for specialty lamps are found in the table below. Specialty lamps are defined as screw-base lamps that are globe, bullet, candle or decorative shaped. These can be medium base, intermediate base, or candelabra base lamps.

Bulb Type (a)	**Base Type (b)**	**Lumen Range (c)**	**$W_{baseline}$ (d)**
Globe All G (G30, G25, G16.5)	E26 and E17	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	6
		180 – 249	10
		250 – 349	13
		350 – 749	22
		750 – 1,049	29
		1,050 – 1,489	37
		1,490 – 2,600	55
		> 2,600	Use ENERGY STAR Watts Equivalent
	E12 (Candela-bra)	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	6
		180 – 249	10
		250 – 349	13
		350 – 499	21
		500 – 1,049	33
		> 1,049	Use ENERGY STAR Watts Equivalent
Globe (G40)	E26 (Medium), E17, and E12	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	6
		180 – 249	10
		250 – 349	13
		350 – 499	21
		500 – 1,049	33
		> 1,049	Use ENERGY STAR Watts Equivalent

Bulb Type (a)	Base Type (b)	Lumen Range (c)	$W_{baseline}$ (d)
Decorative (Shapes B10, B11, B13, BA10, BA11, CA10, C7, C9, F10, F15, ST, S14)	E26 (Medium) and E17	< 70	Use ENERGY STAR Watts Equivalent
		70 – 89	5
		90 – 149	7
		150 – 299	12
		300 – 749	22
		750 – 1,049	29
		1050 – 1,489	37
		1,490 – 2,600	55
		> 2,600	Use ENERGY STAR Watts Equivalent
	Candelabra base E12	< 70	Use ENERGY STAR Watts Equivalent
		70 – 89	5
		90 – 149	7
		150 – 299	12
		300 – 449	20
		450 – 1,049	33
		> 1,049	Use ENERGY STAR Watts Equivalent

<u>Reflector/Flood Lamps</u>

Baseline wattage for reflector and flood type lamps are found in the table below. For reflector and flood lamps that are not covered by the table below, either based on bulb type or lumen output, the manufacturer recommended baseline wattage should be used.

Bulb Type (a)	Lumen Range (b)	$W_{baseline}$ (c)
R20	200 - 299	15
	300 – 718	24
	719 – 810	29
	811 – 1,002	33
	1,003 – 1,202	39
	1,203 – 1,516	47
	1,517 – 1,733	56
	1,734 – 2,184	64
	> 2,184	75

Bulb Type (a)	Lumen Range (b)	$W_{baseline}$ (c)
PAR20	200 - 299	15
	300 – 718	22
	719 – 810	29
	811 – 1,002	33
	1,003 – 1,202	39
	1,203 – 1,516	47
	1,517 – 1,733	56
	1,734 – 2,184	64
	> 2,184	75
BR30, BR40, ER40	200 – 299	15
	300 – 399	20
	400 – 649	26
	650 – 1,419	39
	1,420 – 1,789	50
	1,790 – 2,045	60
	2,046 – 2,578	69
	> 2,578	80
ER30	200 – 299	15
	300 – 399	20
	400 – 956	28
	957 – 1183	35
	1184 – 1419	42
	1420 – 1789	50
	1790 – 2045	60
	2046 – 2578	69
	> 2578	80
PAR30, PAR38, R40	639 – 847	25
	848 – 956	31
	957 – 1,183	35
	1,184 – 1,419	42
	1,420 – 1,789	50
	1,790 – 2,045	60
	2,046 – 2,578	69
	> 2,578	80
R14, PAR16, R16	200 – 299	15
	300 – 399	20
	400 – 499	25
	500 – 599	30
	600 – 1,000	35
MR16	< 450	19
	450 – 600	26
	> 600	36

Bulb Type (a)	Lumen Range (b)	$W_{baseline}$ (c)
For any lamps/bulb types for reflector lamps not captured in the criteria above	All	Use ENERGY STAR Watts Equivalent

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

Look up operating hours from the table below, based on lamp location and city. See details below for derivation of operating hours. "Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. "Unknown" is not a valid selection for direct install programs.

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

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

Hours of operation for interior lighting is estimated to be 2.7 operating hours per day or 986 (2.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[96]

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

Hours of operation for exterior lighting is estimated to be 5.7 operating hours per day or 2,081 (5.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island. [97]

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

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

NYS cities other than NYC, Unknown

Hours of operation for lighting installed in an unknown location is estimated to be 2.8 operating hours per day or 1,022 (2.8 x 365) hours per year. This value is a weighted average of interior and exterior lighting hours derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island.[98]

NYC, Interior

Hours of operation for exterior lighting is estimated to be 4.8 operating hours per day or 1,752 (4.8 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York City and Westchester County.[99]

NYC, Exterior

Hours of operation for exterior lighting is estimated to be 4.4 operating hours per day or 1,606 (4.4 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York City and Westchester County.[100]

NYC, Unknown

Hours of operation for lighting installed in an unknown location is estimated to be 4.8 operating hours per day or 1,752 (4.8 x 365) hours per year. This value is a weighted average of interior and exterior lighting hours derived from on-site lighting inventories of homes in New York City and Westchester County.[101]

LMI LED Table of Hours per Day by Unit Count

The hours per day values prescribed in the table below are intended for use with the Alternate Method for Calculating Annual Energy Savings for LMI Projects established above for General Purpose LEDs. The values in this table are based on the observation that program participants tend to prioritize replacement of the most used bulbs first and, as additional bulbs are replaced, the average hours of use per bulb decreases. For this reason, the hours per day applied to a project replacing 1 -2 bulbs shall be 3.2, while a project replacing 3 – 5 bulbs shall use an hours per day value of 3 and so on.

The values established below reflect the findings and guidance presented in the DOE Residential End-Use Lighting Study, which found average daily hours of use for all residential lamps to be

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

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

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

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

1.6 nationally and in NY state.[102] These values are consistent with those applied in the Em-Power New York program and are subject to change pending future program evaluations.

#Bulbs	Hours/day
1 - 2	3.2
3 - 5	3
6 - 7	2.5
8 - 9	1.5
10 - 16	1

Example Calculation *(Not to be used as default)*

A residential LMI customer replaces ten 60-watt incandescent lamps with 10-watt LED lamps throughout the interior of their home located near Albany. The home has a central AC and gas-furnace. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Summer Peak Coincident Demand Savings

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

Annual Fossil Fuel Energy Savings

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

units = 10, from application
$W_{baseline}$ = 60, from application
W_{ee} = 10, from application
hrs = 986, from Operating Hours section table based on lamp location and city from application
$HVAC_c$ = 0.043, from Appendix D based on building type, HVAC type, and location from application
$HVAC_d$ = 0.073, from Appendix D based on building type, HVAC type, and location from application

[102] DOE Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates, December 2012; Table 4.1

CF = 0.16, from Summary of Variables and Data Sources table based on lamp location from application
$HVAC_{ff}$ = -0.003, from Appendix D based on building type, HVAC type, and location from application

$$\Delta kWh = 10 \times \frac{(60-10)}{1{,}000} \times 986 \times (1+0.043) = 514\ kWh$$

$$\Delta kW = 10 \times \frac{(60-10)}{1{,}000} \times (1+0.073) \times 0.16 = 0.09\ kW$$

$$\Delta MMBtu = 10 \times \frac{(60-10)}{1{,}000} \times 986 \times (-0.003) = -1.48\ MMBtu$$

Alternate Method for Calculating Annual Energy Savings for LMI Projects

General Purpose LEDs

$$\Delta kWh = units\ \times \left(\frac{\Delta W_{LMI,GP} \times 365}{1{,}000}\right) \times hrs$$

units = 10, from application
$\Delta W_{LMI,GP}$ = 46, from application
hrs = 1, from Operating Hours section, LMI LED Table of Hours per Day by Unit Count

$$\Delta kWh = 10\ \times \left(\frac{46 \times 365}{1{,}000}\right) \times 1 = 168\ kWh$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-2	7/31/2013
6-15-3	6/1/2015
1-16-3	12/31/2015
1-17-4	12/31/2016
9-17-2	9/30/2017
12-19-6	12/23/2019
12-19-7	12/23/2019
12-20-13	12/31/2020
7-21-9	8/30/2021
3-22-5	4/29/2022
6-22-19	12/30/2022
3-23-11	3/31/2023

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APPLIANCE RECYCLING

AIR CONDITIONER – ROOM (RAC) RECYCLING

Measure Description

In many cases where an air conditioning unit is replaced, the existing unit is retained, sold, or donated for use elsewhere and represents additional load on the grid. This measure covers recycling of the existing functional equipment, thereby eliminating the consumption associated with that equipment. Air conditioner recycling programs receive energy savings credit for permanently removing inefficient functional air conditioners from the electric grid.

This measure covers the recycling of inefficient room air conditioners in commercial applications. A room air conditioner is a consumer product, other than a "packaged terminal air conditioner," which is powered by a single phase electric current, and which is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating.[103] Minimum energy conservation standards for these appliances have been established by the Code for Federal Regulations 10 CFR 430.32(b). As this standard continues to be revised, and by association ENERGY STAR® standards continue to increase, operational savings attributable to new RAC may justify early retirement before the full useful life has been exhausted. To realize the anticipated savings, a currently functioning appliance 5 years old or older of equivalent cooling capacity and type must be properly disposed of when a new appliance is supplied to the customer.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times EFLH_{cooling}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fossil fuel energy savings

[103] 10 CFR 430.2.

units	= Number of measures recycled under the program
(BTU/h)/unit	= British Thermal Units per hour of air conditioning per unit
$_{baseline}$	= Characteristic of baseline condition
CEER	= Combined Energy Efficiency Ratio
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
(BTU/h)/unit		From application.
$CEER_{baseline}$		If known, use the nameplate efficiency of the recycled equipment, from application. Nameplate EER may be converted to CEER by dividing EER by 1.01 (EER/1.01 = CEER).[104] If unknown, see Baseline Efficiencies section below.
$EFLH_{cooling}$		Cooling equivalent full-load hours by building type, see Appendix G.
CF	NYC: 0.703 Other Cities: 0.305	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.703 for NYC and 0.305 outside of NYC.[105]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is equivalent to the existing equipment. $CEER_{baseline}$ shall be set equal to the nameplate efficiency of the existing unit, converted from EER to CEER via the conversion CEER = EER/1.01, if necessary. If nameplate efficiency is unavailable, use the rated efficiency ratio based on recycled equipment manufacture date, type and capacity per the table below.

Recycled Equipment Manufactured Before June 2014

The CEER values listed in the table below reflect the minimum performance required by the Code of Federal Regulations effective October 1, 2000, to May 31, 2014.[106]

[104] Conversion factor developed by comparing EER and CEER values reported in ENERGY STAR® Program Requirements for Room Air Conditioners Version Eligibility Criteria 3.1.
[105] C&I Unitary HVAC Load Shape Project Final Report, KEMA, 2011, Table 0-6: NY - Inland and NY - Urban/Coastal.
[106] 10 CFR 430.32(b), CFR EER values were converted to CEER values by dividing by 1.01. Conversion factor developed by comparing EER and CEER values reported in ENERGY STAR® Program Requirements for Room Air Conditioners Version Eligibility Criteria 4.1.

Product Type	Product Class Capacity (BTU/h)	Federal Standard With Louvered Sides (CEER)	Federal Standard Without Louvered Sides (CEER)
RAC without Reverse Cycle	< 6,000	9.6	8.9
	6,000 to 7,999	9.6	8.9
	8,000 to 10,999	9.7	8.4
	11,000 to 13,999	9.7	8.4
	14,000 to 19,999	9.6	8.4
	20,000 to 27,999	8.4	8.4
	≥ 28,000	8.4	8.4
RAC with Reverse Cycle	< 14,000	8.9	8.4
	14,000 to 19,999	8.9	7.9
	≥ 20,000	8.4	7.9
Casement Only	All	8.6	
Casement-Slider	All	9.4	

<u>Recycled Equipment Manufactured After June 2014</u>

The CEER values listed in the table below reflect the minimum performance required by the Code of Federal Regulations effective June 1, 2014.[107]

Product Type	Product Class Capacity (BTU/h)	Federal Standard With Louvered Sides (CEER)	Federal Standard Without Louvered Sides (CEER)
RAC without Reverse Cycle	< 6,000	11.0	10.0
	6,000 to 7,999	11.0	10.0
	8,000 to 10,999	10.9	9.6
	11,000 to 13,999	10.9	9.5
	14,000 to 19,999	10.7	9.3
	20,000 to 27,999	9.4	9.4
	≥ 28,000	9.0	9.4
RAC with Reverse Cycle	< 14,000	9.8	9.3
	14,000 to 19,999	9.8	8.7
	≥ 20,000	9.3	8.7
Casement Only	All	9.5	
Casement-Slider	All	10.4	

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the recycling of an existing room air conditioner as defined in the Measure Description section above.

[107] 10 CFR 430.32(b)

Operating Hours

Reference Appendix G for applicable EFLH value for specific building use type and geographic location.

Example Calculation *(Not to be used as default)*

Six room air conditioners with louvered sides and capacity of 7,829 BTU/h each, manufactured in 2012 are recycled by a primary school near Albany. The recycled units have a rated CEER of 9.8. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times EFLH_{cooling}$$

$$\Delta kW = units \times \frac{(BTU/h)/unit}{1{,}000} \times \frac{1}{CEER_{baseline}} \times CF$$

units = 6, from application
(BTU/h)/unit = 7,829 BTU/h, from application
$CEER_{baseline}$ = 9.8, from application
$EFLH_{cooling}$ = 297 hours, from Appendix G based on building type from Small Commercial Cooling EFLH table
CF = 0.305, from Summary of Variables and Data Sources

$$\Delta kWh = 6 \times \frac{7{,}829}{1{,}000} \times \frac{1}{9.8} \times 297 = 1{,}424\ kWh$$

$$\Delta kW = 6 \times \frac{7{,}829}{1{,}000} \times \frac{1}{9.8} \times 0.305 = 1.462\ kW$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Record of Revision

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1-16-15	12/31/2015
4-16-2	3/31/2015
6-17-8	6/30/2017
3-23-12	3/31/2023

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BUILDING SHELL

INSULATION – HOT WATER AND STEAM PIPE

Measure Description

This measure covers the installation of fiberglass or rigid foam/cellular glass pipe insulation in space heating hot water/steam and domestic hot water (DHW) distribution systems on uninsulated copper, steel, CPVC or PEX piping with a nominal diameter between 0.50″ and 8.00″. Estimation of energy savings depend on the type and size of the pipe, type and thickness of the insulation, supply temperature of the heating medium and ambient temperature.

This measure is applicable in retrofit applications and must be installed by a qualified contractor complying with all relevant construction and safety codes and standards. All insulation materials installed under this measure are to be tested in accordance with all pertinent federal testing standards (ASTM) and must be rated for the temperature range of the heating medium conveyed by the affected system. Service hot water pipe insulation is limited to insulation of hot water distribution pipe in unconditioned spaces only. Space heating pipe insulation is limited to insulation installed in unheated spaces only.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,elec} \times 3{,}412} \times l \times \Delta T_{amb} \times hrs \times ElecSF$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{8{,}760} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,fuel} \times 1{,}000{,}000} \times l \times \Delta T_{amb} \times hrs \times FuelSF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
$_{baseline}$	= Characteristic of baseline condition
$_{ee}$	= Characteristic of energy efficient condition
(UA/L)	= Overall heat transfer coefficient per unit length (BTU/h-°F-ft)
E_t	= Thermal efficiency of hot water or steam system
l	= Length of installed insulation (ft) in unconditioned spaces

ΔT_{amb}	= Temperature difference between hot water or steam in pipe and surrounding ambient air temperature (°F)
hrs	= Annual operating hours
ElecSF	= Electric Savings Factor for water heaters: Adjustment to electric water heating energy savings based on water heating fuel
FuelSF	= Fossil fuel Savings Factor for water heaters: Adjustment to fossil fuel water heating energy savings based on water heating fuel
CF	= Coincidence factor
3,412	= Conversion factor, one kWh equals 3,412 BTU
1,000,000	= Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(UA/L)_{baseline}$		Lookup from Baseline Efficiencies section below, based on pipe diameter.
$(UA/L)_{ee}$		Lookup from Compliance Efficiency section below, based on pipe diameter and insulation type and thickness.
$E_{t,elec}$	DHW: 0.98	From application. If unknown, use default thermal efficiency of typical electric storage type water heater provided.[108]
$E_{t,fuel}$	DHW: 0.80 HW and Steam Boilers: See Boiler Efficiencies section below	From application. If unknown, use default efficiency of typical gas storage type water heater and boiler efficiencies provided. [109]
l		From application.
ΔT_{amb}	$T_{pipe} - T_{amb}$	
T_{pipe}	DHW: 125 HW Boiler: 160 Steam Boiler: 212	Average temperature of hot water in distribution system piping (°F). [110]
T_{amb}	DHW: 70 Space Heat: 50	Surrounding average ambient air temperature (°F). [111,112]
ElecSF	Electric WH: 1.0 Fossil Fuel WH: 0 Unknown WH: 0.45 Space Heat: 0	Based on EIA Commercial Buildings Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[113]

[108] Per 10 CFR 431 Subpart G, Appendix B 5.7.1.
[109] Per 10 CFR 431.110 (a).
[110] 10 CFR Appendix E to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.
[111] Average annual ambient temperature in unconditioned spaces.
[112] Average ambient temperature based on typical heating season conditions of unconditioned basements.
[113] EIA Commercial Building Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States, Table B4, Water-heating energy sources (“Unknown” calculated as the number of buildings with electric water heating divided by the total number of buildings with electric or gas water heating).

Variable	Value	Notes
FuelSF	Electric WH: 0 Fossil Fuel WH: 1.0 Unknown WH: 0.55 Space Heat: 1.0	Based on EIA Commercial Buildings Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[114]
hrs	DHW: See Operating Hours section below. Space Heat: $EFLH_{heating}$ (Appendix G)	
CF	Electric WH: 1.0 All Others: N/A	

Boiler Efficiency

Efficiency for commercial boilers is defined by the Code of Federal Regulations (CFR) and subsequently adopted by the Energy Conservation Construction Code of New York State[115] as shown below.

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor for domestic water heating is 1.0.[116]
The prescribed value for the coincidence factor for hot water heating is N/A.

[114] EIA Commercial Building Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States, Table B4, Water-heating energy sources ("Unknown" calculated as the number of buildings with gas water heating divided by the total number of buildings with electric or gas water heating).
[115] ECCCNYS 2020, Table C403.3.2(5).
[116] *No source specified – update pending availability and review of applicable references.*

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is bare copper, steel, CPVC or PEX domestic hot water or space heating piping. Prescribed $(UA/L)_{baseline}$ values are provided in the table below based on the diameter of pipe, pipe material, and application. HDPE piping was not considered.[117] Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Calculations were developed with NAIMA's 3E Plus software program.[118]

Pipe Diameter (in)	$(UA/L)_{baseline}$						
	Bare Copper Piping			Bare Steel Piping		Bare CPVC/PEX Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat	Domestic Hot Water	Hot Water Heat
0.50	0.44	0.48	0.53	0.53	0.59	0.39	0.41
0.75	0.54	0.58	0.64	0.65	0.72	0.48	0.50
1.00	0.65	0.70	0.78	0.79	0.88	0.56	0.58
1.25	0.80	0.86	0.96	0.97	1.09	0.69	0.72
1.50	0.90	0.97	1.09	1.10	1.23	0.78	0.81
2.00	1.10	1.19	1.33	1.34	1.51	0.95	0.98
2.50	1.31	1.42	1.58	1.60	1.80	1.07	1.11
3.00	1.57	1.70	1.90	1.92	2.16	1.23	1.27
3.50	1.77	1.92	2.15	2.18	2.45	1.38	1.42
4.00	1.98	2.14	2.40	2.43	2.73	1.52	1.57
5.00	2.41	2.61	2.92	2.97	3.34	1.82	1.87
6.00	2.84	3.07	3.45	3.50	3.94	2.09	2.15
8.00	3.64	3.94	4.42	4.50	5.06	2.56	2.62

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a length of service hot water or space heating hot water/steam distribution piping insulated in accordance with ECCCNYS[119]. Minimum required insulation thicknesses per material conductivity are outlined in the table below based on fluid operating temperature and pipe diameter ranges.

Fluid Operating Temperature Range and Usage (°F)	Conductivity BTU-in/h-SF-F	Mean Rating Temperature	Nominal Pipe or Tube Size (in)				
			< 1	≥ 1 and < 1.5	≥ 1.5 and < 4	≥ 4 and < 8	8
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5

For piping smaller than 1.5 inches and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted, before thickness adjustment, if necessary, but not to a thickness less than 1 inch. For insulation outside the stated conductivity range, use the

[117] HDPE piping was found to have limited savings potential through preliminarily modeling in 3E Plus® Version 4.1.
[118] Insulation Institute, 3E Plus® Version 4.1.
[119] ECCCNYS 2020, Table C403.11.3 Minimum Pipe Insulation Thickness.

following equation to adjust the minimum required thickness from the table above:

$$T = r \times [(1 + t/r) \times K/k \ - 1]$$

where:

T = minimum insulation thickness
r = actual outside radius of pipe
t = insulation thickness listed in the table for applicable fluid temperature
K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature
k = the upper value of the conductivity range listed in the table for the applicable fluid temperature

The R-value is the thermal resistance of the insulating material, which is derived by dividing the thickness of the material by the material's thermal conductivity, or k-value. Thermal transmittance, or the material's U-factor, is the inverse of the R-value.

The $(UA/L)_{ee}$ values associated with fiberglass and rigid foam/cellular glass insulation of various thicknesses provided in the table below shall be used to establish the compliance condition heat transfer coefficient. Pipe diameter and insulation type and thickness shall be taken from the application. The values below were calculated assuming a k-value of 0.25 BTU-in/hr-°F-SF for fiberglass and 0.35 BTU-in/ hr-°F-SF for rigid foam/cellular glass insulation at 100°F. Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Calculations were developed with NAIMA's 3E Plus software program.[120]

Pipe Diameter (in)	$(UA/L)_{ee}$											
	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1.0 in	1.5 in	2.0 in	2.5 in	3.0 in	0.5 in	1.0 in	1.5 in	2.0 in	2.5 in	3.0 in
0.50	0.12	0.09	0.08	0.07	0.06	0.06	0.16	0.12	0.10	0.09	0.09	0.08
0.75	0.14	0.10	0.09	0.08	0.07	0.07	0.18	0.14	0.12	0.11	0.10	0.09
1.00	0.16	0.12	0.10	0.09	0.08	0.07	0.21	0.16	0.13	0.12	0.11	0.10
1.25	0.19	0.14	0.11	0.10	0.09	0.08	0.24	0.18	0.15	0.13	0.12	0.11
1.50	0.21	0.15	0.12	0.10	0.09	0.09	0.27	0.20	0.16	0.14	0.13	0.12
2.00	0.25	0.17	0.14	0.12	0.11	0.10	0.32	0.23	0.19	0.16	0.15	0.13
2.50	0.29	0.20	0.16	0.13	0.12	0.11	0.37	0.26	0.21	0.18	0.16	0.15
3.00	0.34	0.23	0.18	0.15	0.13	0.12	0.43	0.30	0.24	0.21	0.18	0.17
3.50	0.38	0.26	0.20	0.17	0.15	0.13	0.47	0.33	0.27	0.23	0.20	0.18
4.00	0.42	0.28	0.22	0.18	0.16	0.14	0.52	0.36	0.29	0.25	0.22	0.20
5.00	0.51	0.33	0.26	0.21	0.18	0.16	0.63	0.43	0.34	0.29	0.25	0.23
6.00	0.59	0.38	0.29	0.24	0.21	0.19	0.73	0.50	0.39	0.33	0.28	0.25
8.00	0.75	0.48	0.36	0.30	0.26	0.23	0.91	0.62	0.48	0.40	0.35	0.31

Service hot water pipe insulation for non-recirculating systems is limited to insulation of hot water distribution pipe in unconditioned spaces. Space heating pipe insulation is limited to insulation installed in unheated spaces only.

[120] Insulation Institute, 3E Plus® Version 4.1.

Operating Hours

Savings are assumed to be realized 8,760 hours per year for domestic hot water systems with year-round recirculation. For systems with heating season recirculation only, hours based on location per the table below shall be used. Hours values below were developed from NOAA hourly normals[121] by assuming a 65ºF balance point temperature and summing dry bulb hours below the balance point.

City	hrs
Albany	6,587
Binghamton	7,214
Buffalo	6,727
Massena	7,138
NYC	5,920
Poughkeepsie	6,481
Syracuse	6,671

Operating hours for water and steam boiler space heating systems are prescribed by equivalent full-load hours. Equipment heating EFLH shall be taken from the application. If unknown, default EFLH by facility type, system type and location can be found in Appendix G.

Example Calculation *(Not to be used as default)*

1.0-inch fiberglass insulation is installed on 20 feet of bare 1.25” copper piping located in unconditioned spaces used for distribution of electrically heated domestic hot water in a commercial building. Annual Fossil Fuel Energy Savings are not applicable. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are calculated as below.

$$\Delta kWh = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,elec} \times 3{,}412} \times l \times \Delta T_{amb} \times hrs \times ElecSF$$

$$\Delta kW = \frac{\Delta kWh}{8{,}760} \times CF$$

$(UA/L)_{baseline}$ = 0.80, from baseline efficiency based on pipe material, size, and application
$(UA/L)_{ee}$ = 0.14, from compliance efficiency based on pipe material, size, and application
$E_{t,elec}$ = 0.98; from Summary of Variables and Data Sources table
l = 20, from application.
$\Delta T_{amb} = T_{pipe} - T_{amb}$ = 125-70= 55, from Summary of Variables and Data Sources table based on pipe application
ElecSF = 1.0, from Summary of Variables and Data Sources table
hrs = 8,760, from Summary of Variables and Data Sources table
CF = 1.0, from Summary of Variables and Data Sources table

[121] NOAA National Centers for Environmental Information – NCEI 1991 - 2020 Hourly Normals.

$$\Delta kWh = \frac{0.80 - 0.14}{1.0 \times 3{,}412} \times 20 \times 55 \times 8{,}760 \times 1.0 = 1{,}863.94\ kWh$$

$$\Delta kW = \frac{1{,}863.94}{8{,}760} \times 1.0 = 0.21\ kW$$

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 431 Subpart G – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks, Appendix B - Uniform Test Method for Measuring the Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=e0518d0e0be-fdd3d0f69d20f62691096&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1110.b
2. 10 CFR 431.110 Energy Conservation Standards and Their Effective Dates.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=e0518d0e0be-fdd3d0f69d20f62691096&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1110
3. 10 CFR Appendix E to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.
   Available from: https://www.govinfo.gov/content/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-part430.pdf
4. EIA Commercial Building Energy Consumption Survey (CBECS) 2012 Survey Data for Middle Atlantic States, May 2016.
   Available from: https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b4.php
5. ECCCNYS 2020 Table C404.2 Minimum Performance of Water-heating Equipment & Table C403.11.3 Minimum Pipe Insulation Thickness.
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency
6. 3E Plus, NAIMA, Insulation Institute, Version 4.1.
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Record of Revision

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12-18-9	12/28/2018
12-20-6	12/31/2020
3-23-14	3/31/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

ENERGY AND HEAT RECOVERY VENTILATOR

Measure Description

This measure covers the installation of AHRI 1060 or HVI 920 certified Energy Recovery Ventilator (ERV) and Heat Recovery Ventilator (HRV) equipment on an existing HVAC system. ERVs and HRVs reduce heating and cooling loads while maintaining required ventilation rates by facilitating heat transfer between outgoing conditioned air and incoming outdoor air. ERVs and HRVs employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an HVAC system.[122] This measure only applies in cases where ERV/HRV functionality is not required by federal, state, local or municipal codes or standards. This measure is only applicable to retrofit of existing buildings. For the purposes of this measure, ERVs and HRVs are distinguished as follows:

Energy Recovery Ventilator (ERV)
Transfers both sensible (heat content) and latent (moisture content) heat between supply and exhaust airstreams.

Heat Recovery Ventilator (HRV)
Transfers sensible heat only between supply and exhaust airstreams.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings (for ERVs)

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}\right)$$

$$\Delta kWh_{cooling} = \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times Eff_{ElecCool}}\right) \times hrs_{cooling}$$

$$\Delta kWh_{heating} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000 \times Eff_{ElecHeat}} \times F_{ElecHeat}\right) \times hrs_{heating}$$

$$\Delta kWh_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times \left(hrs_{heating} + hrs_{cooling}\right)$$

[122] AHRI Guideline V (I-P)-2011 Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems.

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times EER}\right) \times CF + \Delta kW_{fan}$$

$$\Delta kW_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000{,}000 \times Eff_{FuelHeat}} \times F_{FuelHeat} \times hrs_{heating}$$

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings (for HRVs)

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}\right)$$

$$\Delta kWh_{cooling} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,cooling} - T_{indoor,cooling}\right)}{1{,}000 \times Eff_{ElecCool}}\right) \times hrs_{cooling}$$

$$\Delta kWh_{heating} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000 \times Eff_{ElecHeat}} \times F_{ElecHeat}\right) \times hrs_{heating}$$

$$\Delta kWh_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times \left(hrs_{heating} + hrs_{cooling}\right)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,cooling} - T_{indoor,cooling}\right)}{1{,}000 \times EER}\right) \times CF + \Delta kW_{fan}$$

$$\Delta kW_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times CF$$

where:

$$kW_{fan} = \sum\left(\frac{CFM \times \Delta P}{\frac{33{,}013}{5.202} \times Eff_{fan,mech} \times Eff_{fan,motor}} \times 0.746\right)$$

Or, if any of the above values are unknown (and for baseline supply/exhaust fans):

$$kW_{fan} = \sum\left(\frac{HP \times LF}{Eff_{fan,motor}} \times 0.746\right)$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000{,}000 \times Eff_{FuelHeat}} \times F_{FuelHeat} \times hrs_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline or Existing condition
$_{ee}$	= Efficient condition
kW_{fan}	= Total electric power of conventional and ERV/HRV supply and exhaust fans (kW). Sigma operator included to indicate that this term shall include consideration of all supply and exhaust fans in baseline and efficient cases.
$_{heating}$	= Property of heating season
$_{cooling}$	= Property of cooling season
CFM	= Volume of supply air in Cubic Feet per Minute
CF	= Coincidence Factor
LF	= Load Factor
$Eff_{hx,total}$	= Total Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[123] or Total Recovery Efficiency rated in accordance with HVI 920[124]
$Eff_{hx,sens}$	= Sensible Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[125] or Sensible Recovery Efficiency rated in accordance with HVI 920[126]
$Eff_{ElecCool}$	= Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (≥65,000 BTU/h)

[123] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
[124] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge
[125] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
[126] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge

$Eff_{ElecHeat}$ = Seasonal average energy efficiency of electric heating equipment. Heating Seasonal Performance Factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heating) during the heating season / total electric energy heat pump consumed (in watt-hour); if equipment efficiency is reported in COP, convert to HSPF using the equivalency HSPF = COP x 3.412
EER = Energy efficiency ratio under peak conditions (BTU/watt-hour)
$Eff_{FuelHeat}$ = Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)
$Eff_{fan,mech}$ = Mechanical efficiency of ERV fans
$Eff_{fan,motor}$ = Efficiency of ERV fan motors
$F_{ElecHeat}$ = Electric heating factor, used to account for the presence or absence of an electric heating system
$F_{FuelHeat}$ = Fossil fuel heating factor, used to account for the presence or absence of a fossil fuel heating system
T_{indoor} = Indoor air temperature, in °F
$T_{outdoor}$ = Outdoor air temperature, in °F
ΔP = Supply or exhaust air pressure drop at nominal airflow in the ERV as rated in accordance with AHRI Standard 1060, in inches of water
$H_{outdoor}$ = Enthalpy of outside air in BTU/lb
H_{indoor} = Enthalpy of inside air at 70°F, in BTU/lb
$hrs_{heating}$ = Operating hours in the heating season
$hrs_{cooling}$ = Operating hours in the cooling season
4.5 = Density of inlet air at 70ºF x 60 min/hr, in lb-min/ft^3-hr
1.08 = Specific heat of air × density of inlet air @ 70˚F × 60 min/hr[127] in BTU/h-ºF CFM
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU
33,013 = Conversion factor from horsepower to ft.lb/min
5.202 = Conversion factor from inches of water to pounds per square ft (lb/sq.ft.)
0.746 = Conversion factor (kW/hp), 746 watts equals one electric horsepower
1,000 = Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
CFM		From application.
$Eff_{hx,total}$		From application.
$Eff_{hx,sens}$		From application.
$Eff_{ElecCool}$		From application. SEER or IEER shall be used, based on nameplate rating metric of existing equipment. For equipment rated in SEER2, SEER2 rating shall be used.
$Eff_{FuelHeat}$		From application, E_c, E_t, or AFUE shall be used, based on nameplate rating metric of existing equipment.

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

Variable	Value	Notes
$Eff_{ElecHeat}$		From application. HSPF shall be used, based on nameplate rating metric of existing equipment. If equipment is rated in COP, convert to HSPF using the equivalency HSPF = COP x 3.412. For equipment rated in HSPF2, HSPF2 rating shall be used.
EER		From application. For equipment rated in EER2, EER2 rating shall be used. If unknown, EER is established as follows[128]: $EER = (1.12 \times SEER) - (0.02 \times SEER^2)$
$Eff_{fan,mech}$		From application.
$Eff_{fan,motor}$		From application.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise use 0.0.
$H_{outdoor}$		Lookup from Climate Data table below based on location[129]
H_{indoor}		If indoor set temperature is known, lookup from Indoor Enthalpy table below. Otherwise, use 25.3 based on 70°F and 50% RH indoor air conditions.
T_{indoor}		From application or use 70°F
$T_{outdoor}$		Average of temperatures from the heating and cooling season based on the city. Lookup value from table below.
ΔP		From application.
$hrs_{heating}$		Look up interval hours in the Operating Hours section table below based on location.
$hrs_{cooling}$		Look up interval hours in the Operating Hours section table below based on location.
CF	0.8	
LF		From application. If unknown use 0.92 as default value.[130]

Indoor Enthalpy (H_{indoor})

Temperature (°F)	Relative Humidity	Enthalpy (H_{indoor})
65	50%	22.7
66	50%	23.2
67	50%	23.7
68	50%	24.2
69	50%	24.8
70	50%	25.3
71	50%	25.8

128 DOE, Building America House Simulation Protocols, October 2010; for equipment rated in SEER2, replace SEER with SEER2 and EER with EER2 in the derivation formula.
129 NCEI 1991-2020 Annual/Seasonal Climate Normals.
130 Cascade Energy. "Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors." Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012.

Temperature (°F)	Relative Humidity	Enthalpy (H_{indoor})
72	50%	26.4
73	50%	27.0
74	50%	27.5
75	50%	28.1
76	50%	28.7
77	50%	29.3
78	50%	29.9

Outdoor Air Temperature & Enthalpy

Look up outdoor air temperature and enthalpy based on the city in the table below. The table below summarizes the average outdoor air temperature and enthalpy during the Heating (<65°F) and Cooling (>65°F) seasons across a typical climatological year.[131]

City	$T_{outdoor,heating}$ (°F)	$T_{outdoor,cooling}$ (°F)	$H_{outdoor,heating}$ (Btu/lb)	$H_{outdoor,cooling}$ (Btu/lb)
Albany	41.89	72.09	11.80	29.57
Binghamton	41.77	70.45	11.30	28.04
Buffalo	42.02	71.36	12.10	28.80
Massena	39.07	71.84	12.10	29.18
NYC	45.90	73.10	14.34	30.86
Poughkeepsie	43.08	73.28	13.78	30.66
Syracuse	41.88	71.95	11.94	29.33

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[132]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition for this measure is a building with an ASHRAE 62.2-compliant exhaust fan system with no heat or energy recovery.

Compliance Efficiency from which Incentives are Calculated

The compliance condition for this measure is a building with an ASHRAE 62.2-compliant exhaust fan system equipped with AHRI 1060 or HVI 920 certified ERV or HRV components.

Operating Hours

Lookup hours in the table below based on location and most appropriate facility operating schedule. Default HVAC system load hours were developed from NOAA hourly normals by assuming a 65ºF balance point temperature and summing dry bulb hours above the balance point for HVAC

[131] NOAA National Centers for Environmental Information – NCEI 1991 - 2020 Hourly Normals.
[132] *No source specified – update pending availability and review of applicable references.*

cooling and below the balance point for HVAC heating during building operating hours.[133] Operating hour assumptions for facility types are described in Appendix A.

Typical Operating Schedule	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
24/7 - 365 Cooling Hours	1,937	1,367	1,793	1,470	2,684	2,054	1,845
24/7 - 365 Heating Hours	6,587	7,214	6,727	7,138	5,920	6,481	6,671
Mon-Sun 6AM-12AM Cooling Hours	1,760	1,346	1,636	1,470	2,152	1,893	1,708
Mon-Sun 6AM-12AM Heating Hours	4,677	5,098	4,789	4,972	4,303	4,544	4,726
Mon-Sun 6AM-10PM Cooling Hours	1,601	1,243	1,499	1,401	1,946	1,739	1,565
Mon-Sun 6AM-10PM Heating Hours	4,121	4,499	4,215	4,344	3,796	3,984	4,157
Mon-Fri 7AM-7PM Sun 11AM-6PM Cooling Hours	1,040	812	989	926	1,220	1,150	1,024

133 NOAA National Centers for Environmental Information – NCEI 1991 - 2020 Hourly Normals.

Typical Operating Schedule	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Mon-Fri 7AM-7PM Sun 11AM-6PM Heating Hours	2,367	2,615	2,432	2,497	2,204	2,264	2,386
Mon-Fri 7AM-7PM Cooling Hours	910	702	869	808	1,081	1,008	896
Mon-Fri 7AM-7PM Heating Hours	2,139	2,367	2,192	2,258	1,984	2,047	2,156
Mon-Fri 7AM-5PM Cooling Hours	717	536	700	630	890	794	711
Mon-Fri 7AM-5PM Heating Hours	1,821	2,021	1,846	1,925	1,663	1,749	1,828

Example Calculation *(Not to be used as default)*

An ERV delivering 4,000 CFM is installed in a commercial building with an existing continuous operation ¼ hp exhaust fan system of 70% efficiency and a 1.0 load factor located near Albany. The ERV has a sensible effectiveness of 65% and total effectiveness of 62%. The building is cooled by a central air conditioner with 15 SEER and heated by an 80% thermal efficient gas fired hot water boiler, where the indoor cooling temperature is set at 71ºF and the indoor heating temperature is set at 69ºF. The ERV fan has a motor efficiency of 80%, a mechanical efficiency of 65%, and a pressure drop of 0.6 inches of water. The building's typical operating schedule is Mon – Fri from 7AM – 7PM and Sunday 11AM – 6PM. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times \left(\Delta kWh_{cooling} + \Delta kWh_{heating} + \Delta kWh_{fan}\right)$$

$$\Delta kWh_{cooling} = \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times Eff_{ElecCool}}\right) \times hrs_{cooling}$$

$$\Delta kWh_{heating} = \left(\frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000 \times Eff_{ElecHeat}} \times F_{ElecHeat}\right) \times hrs_{heating}$$

$$\Delta kWh_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times \left(hrs_{heating} + hrs_{cooling}\right)$$

$$\Delta kW = units \times \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,cooling} - H_{indoor,cooling}\right)}{1{,}000 \times EER}\right) \times CF + \Delta kW_{fan}$$

$$\Delta kW_{fan} = \left(kW_{fan,baseline} - kW_{fan,ee}\right) \times CF$$

where:

$$kW_{fan} = \sum\left(\frac{CFM \times \Delta P}{\frac{33{,}013}{5.202} \times Eff_{fan,mech} \times Eff_{fan,motor}} \times 0.746\right)$$

Or, if any of the above values are unknown (and for baseline supply/exhaust fans):

$$kW_{fan} = \sum\left(\frac{HP \times LF}{Eff_{fan,motor}} \times 0.746\right)$$

$$\Delta MMBtu = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,heating} - T_{outdoor,heating}\right)}{1{,}000{,}000 \times Eff_{FuelHeat}} \times F_{FuelHeat} \times hrs_{heating}$$

units = 1, from application
CFM = 4,000, from application
$Eff_{hx,total}$ = 0.62, from application
$H_{outdoor,cooling}$ = 29.57 BTU/lb, from Outdoor Air Temperature & Enthalpy table based on location from application
$H_{indoor,cooling}$ = 25.8 BTU/lb, from on Indoor Enthalpy table based on indoor temperature from application
$Eff_{ElecCool}$ = 15, from application
EER = (1.12 x 15) – (0.02 x 15^2) = 12.3, from Summary of Variables and Data Sources table
$kW_{fan,ee}$ = (4,000 x 0.6) / (33,013/5.202 x 0.65 x 0.80) x 0.746 = 0.542 kW
    ΔP = 0.6, from application
    $Eff_{fan,mech}$ = 0.65, from application
    $Eff_{fan,motor}$ = 0.80, from application
$kW_{fan,baseline}$ = (0.25 x 1.0) / .70 x 0.746 = 0.266 kW
    HP = 0.25, from application

LF = 1.0, from application
$Eff_{fan,motor}$ = 0.70, from application
$hrs_{cooling}$ = 1,291, from Operating Hours table based on location and operating schedule from application
$Eff_{hx,sens}$ = 0.65, from application
$T_{indoor,heating}$ = 68ºF, from application
$T_{outdoor,heating}$ = 41.89ºF, from Outdoor Air Temperature & Enthalpy table based on location from application
$Eff_{ElecHeat}$ = N/A, from application
$F_{ElecHeat}$ = 0, from application
$hrs_{heating}$ = 2,857, from Operating Hours table based on location and operating schedule from application
CF = 0.8, from Summary of Variables and Data Sources table
$Eff_{FuelHeat}$ = 0.80, from application
$F_{FuelHeat}$ = 1, from application

$$kW_{fan,ee} = \sum\left(\frac{4{,}000 \times\ 0.6}{\frac{33{,}013}{5.202} \times 0.65 \times 0.80} \times 0.746\right) = 0.542\ kW$$

$$kW_{fan,baseline} = \sum\left(\frac{0.25 \times\ 1}{0.70} \times 0.746\right) = 0.266\ kW$$

$$\Delta kWh_{cooling} = \left(\frac{4.5 \times 4{,}000 \times 0.62 \times (29.57 - 25.8)}{1{,}000 \times 15}\right) \times 1{,}291 = 3{,}621.10\ kWh$$

$$\Delta kWh_{heating} = 0\ kWh$$

$$\Delta kWh_{fan} = (0.266 -\ 0.542)\ \times\ (2{,}857 + 1{,}291) = -1{,}144.85\ kWh$$

$$\Delta kWh = 1 \times (3{,}621.10 + 0 + (-1{,}145)\ ) = 2{,}476.10\ kWh$$

$$\Delta kW_{fan} = (0.266 -\ 0.542)\ \times 0.8 =\ -0.221\ kW$$

$$\Delta kW\ = 1 \times \left(\frac{4.5 \times 4{,}000 \times 0.62 \times (29.57 - 25.8)}{1{,}000 \times 12.3}\right) \times 0.8 + (-0.221) = 2.51\ kW$$

$$\Delta MMBtu = \frac{1.08 \times 4{,}000 \times 0.65 \times (69 - 41.89)}{1{,}000{,}000 \times 0.80} \times 1 \times 2{,}857 = 271.86\ MMBtu$$

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

Employing ERVs in the winter may exchange latent heat decreasing the need to run a humidifier, but the impact is expected to be negligible and is not quantified in the prescribed estimation methodology for this measure at this time.

References

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2. AHRI Standard 1060 (I-P), 2018 Standard for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
   Available from: https://www.ahrinet.org/sites/default/files/2022-06/AHRI_Standard_1060_I-P_2018.pdf
3. HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge, February 2020
   Available from: https://hvi.iwrapper.com/HVI_Certification_Program_Policies/Publication_920
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6. Cascade Energy. “Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors.” Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012.
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Record of Revision

Record of Revision Number	Issue Date
7-20-12	7/31/2020
6-22-11	9/2/2022
3-23-15	3/31/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

HEAT PUMP – AIR SOURCE (CCASHP)

Measure Description

This measure covers the installation of cold climate Air Source Heat Pump (ccASHP) systems[134] with total rated heating capacity less than 300,000 BTU/h that provide heating and cooling for space conditioning in commercial applications, including high rise multifamily buildings of four or more stories[135] or with an occupied floor located more than 75 feet above the lowest level of fire department vehicle access.[136] An air source heat pump is a product, other than a packaged terminal heat pump or single package vertical heat pump, which is powered by single phase electricity, air cooled, not contained within the same cabinet as a furnace that is rated above 225,000 BTU/h, and operates as a heat pump in both heating and cooling mode. This measure applies to central ducted systems, single zone split-systems with ductless indoor units that may be wall-mounted, floor-mounted, or ceiling-mounted and multi-zone split systems with one outdoor section and multiple indoor sections. These indoor sections may be a combination of ductless or compact ducted units.

This measure is based on several assumptions consistent with best practice design for a quality ASHP installation:

- NYS code and Federal Standard (ECCCNYS 2020, Code of Federal Regulations 10 CFR 430.32, 431.77, 431.87) or local legislation applicable at the time of installation should be referenced for correct baseline system and efficiency values.

- Building heating and cooling loads shall be calculated, and systems shall be sized, in accordance with applicable federal, state, local and municipal codes and standards.

- When the building peak heating load for a small commercial building in New York State exceeds the peak cooling load, it is assumed that the ASHP runs at part-load during peak cooling hours. For installation scenarios where the building load is cooling dominant a custom analysis is required.

The ASHP efficiency must meet the Northeast Energy Efficiency Partnerships (NEEP) Cold Climate Air Source Heat Pump (ccASHP) Specification (Version 4.0) effective January 1, 2023. The specification uses AHRI-certified performance ratings and manufacturer reported data to describe the efficiency and capacity of the unit under full and part load conditions. This equipment is rated under ANSI/AHRI 210/240.

[134] NEEP Cold Climate Air Source Heat Pump (ccASHP) Specification (Version 4.0) effective January 1, 2023
[135] NYSERDA, Mid- and High-Rise Multifamily Buildings.
[136] NYSBC 2020; Chapter 2 Definitions: High-Rise Building.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \Bigg(\bigg(BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{SEER_{baseline}} - \frac{1}{EER_{season,ee}}\right) \times BEFLH_{cooling} \times F_{load,cooling}\bigg) + \bigg(BHL \times \frac{1}{1{,}000} \times \left(\frac{F_{ElecHeat}}{COP_{season,baseline}} - \frac{1}{COP_{season,ee}}\right) \times \frac{1}{3.412} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}\bigg) - \bigg(BHL \times \frac{1}{1{,}000} \times F_{ElecHeat,new} \times \frac{1}{3.412} \times BEFLH_{heating} \times \left(1 - F_{load,heating} \times F_{ctrl}\right)\bigg)\Bigg)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times F_{load,cooling} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = BHL \times \frac{1}{1{,}000{,}000} \times \frac{F_{FuelHeat}}{Eff_{baseline}} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fossil fuel energy savings
BCL = Building Cooling Load at design conditions (BTU/h)
BHL = Building Heating Load at design conditions (BTU/h)
$F_{ElecHeat}$ = Electric heating factor; used to account for the presence or absence of an electric heating system
$F_{ElecHeat,new}$ = New electric heating factor; used to account for a new heat pump’s reliance on supplemental electric resistance heat to meet full heating load
$F_{FuelHeat}$ = Fossil fuel heating factor; used to account for the presence or absence of a fossil fuel heating system
$_{baseline}$ = Characteristic of baseline condition
$_{ee}$ = Characteristic of energy efficient condition
SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, used for average U.S. location/region
EER = Full load energy efficiency ratio (BTU/watt-hour)
EER_{season} = Seasonally adjusted average energy efficiency (BTU/watt-hour)
COP = Coefficient of performance for heating, ratio of output energy/input energy
COP_{season} = Seasonally adjusted average coefficient of performance
Eff = Efficiency rating of fossil fuel heating equipment
$BEFLH_{cooling}$ = Cooling equivalent full-load hours based on building design load
$BEFLH_{heating}$ = Heating equivalent full-load hours based on building design load

$F_{load,cooling}$	= Adjustment factor to account for the portion of the seasonal[137] cooling load met by the heat pump
$F_{load,heating}$	= Adjustment factor to account for the portion of the seasonal[138] heating load met by the heat pump
F_{ctrl}	= Factor to modify heating load fraction when optional control features are used.
CF	= Coincidence Factor
3.412	= Conversion factor, one watt-hour equals 3.412 BTU
1,000	= Conversion factor, one kilowatt equals 1,000 watts
1,000,000	= Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
BCL		Building cooling load at design conditions, from application.
BHL		Building heating load at design conditions, from application.
$F_{ElecHeat}$		If the baseline heating system is an electric system, set equal to 1. Otherwise, set equal to 0.
$F_{ElecHeat,new}$		If the efficient case heat pump system relies on newly installed supplemental electric resistance heat capacity to meet the peak load, set equal to 1. Otherwise, set equal to 0.
$F_{FuelHeat}$		If the baseline heating system is a fossil fuel system, set equal to 1. Otherwise, set equal to 0.
$SEER_{baseline}$		Electric cooling seasonal energy efficiency rating of baseline equipment. See Baseline Efficiencies section below for details.
$EER_{baseline}$		Electric cooling full load energy efficiency rating of baseline equipment. See Baseline Efficiencies section below for details.
EER_{ee}		Electric cooling full load energy efficiency rating of efficient equipment. See Compliance Efficiency section below for details.
$EER_{season,ee}$		Seasonally adjusted energy efficiency ratio of the efficient equipment. See Compliance Efficiency section below for details.
$COP_{season,baseline}$		Seasonally adjusted Coefficient of Performance of the baseline equipment. The assumed COP of an electric resistance/electric furnace system is 1.0. If the baseline is a conventional ASHP[139], use the baseline calculations below.
$COP_{season,ee}$		Seasonally adjusted Coefficient of Performance of the efficient equipment. See Compliance Efficiency section below for details.
$Eff_{baseline}$		Fossil fuel energy efficiency of the baseline equipment. See Baseline Efficiency section below for details.

[137] Fraction of annual (vs. design) cooling load served by the equipment as shown in the Cooling Load Factor table.
[138] Fraction of annual (vs. design) heating load served by the equipment as shown in the Heating Load Factor table.
[139] In this context, "conventional ASHP" is defined as a minimally code-compliant non-NEEP listed ASHP with efficiency ratings as indicated in the Baseline Efficiencies section below.

Variable	Value	Notes
$BEFLH_{cooling}$		Lookup based on building type, vintage and location from the appropriate table in the Operating Hours section below.
$BEFLH_{heating}$		Lookup based on building type, vintage and location from the appropriate table in the Operating Hours section below.
$F_{load,cooling}$		Lookup based on equipment sizing and control parameters from the Cooling Load Factor table below.
$F_{load,heating}$		Lookup based on equipment sizing and control parameters from the Heating Load Factor table below.
F_{ctrl}		Lookup based on optional control features Control Factor table (equals 1 for default control)
CF	0.80	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.80.[140]

Baseline Efficiencies from which Energy Savings are Calculated

The baselines used in this measure are determined by the type of equipment that would have been installed without the influence of the program supporting the installation of this measure. This allows for an analysis that does not depend on a typical 'like-for-like' replacement scenario.

An ASHP system can be considered a normal replacement scenario for electric resistance heating (with or without a central electric cooling system), an ASHP system (that provides space heating and cooling), or a fossil fuel fired heating system (with or without a central electric cooling system). The tables below provide baseline efficiencies for electric cooling and heating and fossil fuel fired heating systems.

For scenarios where there is new construction or substantial renovation, the baseline is assumed to be a fossil fuel fired warm air furnace of the fuel type most likely to be installed at the project site without the influence of the program with a central air conditioning system.

The baseline efficiency for electric cooling and heating systems is defined by the Code of Federal Regulations as shown in the table below.

Electric Cooling and Heating System Baseline Efficiencies

Product Class	Seasonal Energy Efficiency Ratio (SEER)[141]	Energy Efficiency Ratio (EER)	Heating Seasonal Performance Factor (HSPF)[142]
Split System – Air Conditioner (<45 kBTU/h)	13.0	11.2	N/A

[140] *No source specified – update pending availability and review of applicable references.*
[141] 10 CFR 430.32(c)(1).
[142] 10 CFR 430.32(c)(1).

Product Class	Seasonal Energy Efficiency Ratio (SEER)[141]	Energy Efficiency Ratio (EER)	Heating Seasonal Performance Factor (HSPF)[142]
Split System – Air Conditioner (≥45 and <65 kBTU/h)	13.0	11.2	N/A
Single Package – Air Conditioner	14.0	11.8	N/A
Split System – Heat Pump (<45 kBTU/h)	14.0	11.8	8.2
Split System – Heat Pump (≥45 and < 65 kBTU/h)	14.0	11.8	8.2
Single Package – Heat Pump (<65 kBTU/h)	14.0	11.8	8.0

The baseline efficiency for commercial fossil fuel fired heating systems is defined by International Energy Conservation Code[143] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

Commercial Fossil Fuel Fired Heating System Baseline Efficiencies

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6[144]
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.80 AFUE
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE
	≥ 225 kBTU/h	0.81 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec

143 ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5).
144 AFUE: Annual Fuel Utilization Efficiency; Et: Thermal Efficiency; Ec: Combustion Efficiency

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6[144]
Boiler, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

For scenarios where the baseline heating system is electric resistance heat or an electric furnace, the baseline efficiency is assumed to be a COP of 1.0.

For scenarios where the baseline heating system is a conventional ASHP, additional consideration is given to account for the significant difference between the rating conditions for HSPF and the typical operating conditions in New York State, as shown below:

The HSPF is the AHRI-rated heating seasonal average efficiency expressed in terms of BTU/watt-hour. A seasonally adjusted $COP_{baseline}$ of a conventional air-source heat pump is used in the above equations. This adjusted baseline COP shall be calculated as:

$$COP_{season,baseline} = \frac{HSPF \times F_{HSPF}}{3.412}$$

where:

HSPF = Heating seasonal performance factor of the baseline system
F_{HSPF} = HSPF Climate Adjustment Factor, from table below
3.412 = Conversion factor, one watt-hour equals 3.412 BTU

<u>HSPF Climate Adjustment Factor (F_{HSPF}) for Conventional ASHP Used as a Baseline</u>

City	HSPF < 8.5	HSPF ≥ 8.5
Albany	0.70	0.67
Binghamton	0.68	0.65
Buffalo	0.73	0.70
Massena	0.59	0.56
NYC	0.80	0.78
Poughkeepsie	0.62	0.59
Syracuse	0.69	0.66

For scenarios where the baseline cooling system is a conventional ASHP, climate adjustment factors for cooling efficiency are not provided. Differences between SEER rating conditions and typical operating conditions in New York State and cooling load are anticipated to have negligible impact on predicted savings.

Compliance Efficiency from which Incentives are Calculated

ASHPs are rated under ANSI/AHRI 210/240. Cold climate ASHPs must meet the Northeast Energy Efficiency Partnerships (NEEP) Cold Climate Air Source Heat Pump (ccASHP) Specification (Version 4.0) effective January 1, 2023. The specification uses AHRI-certified performance ratings and manufacturer reported data to describe the efficiency and capacity of the unit under full and part load condition.

The average seasonal heating efficiency for an ASHP with a variable speed compressor is calculated as:

$$COP_{season,ee} = a + b \times HSPF \times \frac{1}{3.412}$$

The average seasonal cooling efficiency for a ccASHP with a variable speed compressor is calculated as:

$$EER_{season,ee} = c + d \times SEER$$

where:

a & b	= Offset and slope coefficients from Tables below for heating (select based on city and scenario)
c & d	= Offset and slope coefficients from Tables below for cooling (select based on city and scenario)
HSPF	= Rated Heating Season Performance Factor from AHRI or derived based on guidance in Efficiency Conversion section below
SEER	= Rated Seasonal Energy Efficiency Ratio from AHRI or derived based on guidance in Efficiency Conversion section below
3.412	= Conversion factor, one watt-hour equals 3.412 BTU

Note that the cooling efficiency adjustments are quite large for some ASHP units (mini-splits) but much smaller for central ducted ASHP units. For the baseline conventional ASHP we assume that no adjustment to SEER is required. Appendix F in the ASHP White Paper explains why some ASHP units require a cooling efficiency adjustment while others do not.

Summary of Variables and Data Sources

Variable	Value	Source
a & b		Coefficients to represent offset and slope from the table below to determine seasonal heating efficiency ($COP_{season,ee}$) from HSPF. Depends on city and scenario.
c & d		Coefficients to represent offset and slope from the table below to determine seasonal cooling efficiency ($EER_{season,ee}$) from SEER. Depends on city and scenario.
HSPF		Rated heating season performance factor from AHRI or derived based on guidance in Efficiency Conversion section below
SEER		Rated seasonal energy efficiency ratio from AHRI or derived based on guidance in Efficiency Conversion section below

Efficiency Conversion

For equipment with seasonal heating and cooling efficiency ratings in HSPF2 and SEER2 per AHRI, respectively, efficiency ratings shall be converted to HSPF and SEER as follows:

$$HSPF = HSPF2/F_{HSPF2}$$

$$SEER = SEER2/F_{SEER2}$$

Where F_{HSPF2} and F_{SEER2} are established based on equipment type per the table below.[145]

Equipment Type	F_{HSPF2}	F_{SEER2}
Ductless System[146]	0.90	1.00
Centrally Ducted Split System[147]	0.85	0.95
Centrally Ducted Single Packaged System	0.84	0.95

The scenarios shown in the first column of the Whole Building and Displacement Scenarios table below represent various specific applications of heat pumps, with heat pump type, sizing, and control strategy shown. These scenarios may be considered "sub-measures" of this measure[148]. Assigning applicable scenario(s) to program participants or participant groups is the responsibility of program designers and implementers. For reference, the control strategies listed in the Whole Building and Displacement Scenarios table below are defined as follows:

- **Separate:** The ASHP and backup heating system are on separate thermostats and there is no effort to lock out the heat pump at cold temperatures when the backup system is running.

[145] Conversion factors developed by AHRI and adopted by RESNET, as published in Draft PDS-02 MINHERS® Addendum 71f, SEER/HSPF2 Conversions, RESNET, January 2023

[146] Applies to all scenarios labeled 2 and 3 (i.e., 2a – 2h and 3a – 3c) in the Whole Building and Displacement Scenarios table below

[147] Applies to all scenarios labeled 1 and 4 (i.e., 1a – 1d and 4a – 4d) in the Whole Building and Displacement Scenarios table below

[148] Detailed descriptions of these scenarios and their parameters are found in the white paper *Savings Calculations for Residential Air Source Heat Pumps: The Basis for Modifying EFLH and Seasonal Efficiency Factors for "Whole House" and "Displacement" Applications*, Tables 2 and 3, and the associated narrative.

- **Integrated:** The ASHP and backup heating system are on the same thermostat. The backup heater can modulate (or cycle ON and OFF) to meet the load without limiting the ASHP from delivering its maximum capacity. Also called “Droop” control in the Clean Heat Program.

The Separate and Integrated control options in the table only apply to the Part Load or Displacement scenarios. The impact of optional control features for Whole Building or Full Load are accounted for by the control factor (F_{ctrl}) in the table below. “Single-zone ductless” means the equipment is single-zone (1-to-1 indoor to outdoor units). There may be multiple single-zone systems to achieve the HP sizing shown. When multiple HPs are used, the capacity-weighted rated efficiencies (HSPF, SEER, and EER) for the installed units need to be determined. For both cooling and heating efficiencies, use the rated cooling capacity at 95°F for each unit to find the weighted average for HSPF, SEER and EER.

Whole Building and Displacement Scenarios

Scenario	Description	ASHP Type	Application	Controls	HP Sizing Parameter
1a – 1c	Central ASHP	Central, Ducted	Whole or Full Load	(see F_{ctrl} table)	0.9
1d					1.0
2a	Ductless Mini-Spilt sized at 30%, 50%, 70% and 90/100%	Single-Zone Ductless	Displace or Part Load	Separate	0.3
2b					0.5
2c					0.7
2d				Integrated	0.3
2e					0.5
2f					0.7
2g			Whole or Full Load	(see F_{ctrl} table)	0.9
2h					1.0
3a	Ductless Multi-Split sized to 70% and 90/100%	Multi-Zone Ductless	Displace or Part Load	Separate	0.7
3b			Whole or Full Load	(see F_{ctrl} table)	0.9
3c					1.0
4a	Compact Ducted Mini-Split sized to 50% ,70% and 90/100%	Single-Zone Compact Ducted	Displace or Part Load	Separate	0.5
4b					0.7
4c			Whole or Full Load	(see F_{ctrl} table)	0.9
4d					1.0

The HP Sizing Parameter should be determined using the maximum heating capacity at 17°F ($QH_{17,max}$) for projects best represented by the New York City climate zone and maximum heating capacity at 5°F from the NEEP Cold Climate Heat Pump List ($QH_{5,max}$) otherwise. BHL is the design heating load for the building:

$$\text{HP Sizing Parameter} = (QH_{17,max} \text{ or } QH_{5,max}) / BHL$$

The HP Sizing Parameter corresponds to the rightmost column in the Whole Building and Displacement Scenarios table above. Choose an appropriate scenario, then use the coefficients from the tables below to determine the seasonal efficiencies and load factors. When the HP Sizing Parameter falls between the values in the column, use the scenario with the lower value.

Note that the HP Sizing Parameter is a factor of convenience for use in this section. It is not necessarily the same as the Actual Sizing Ratio that the participating installers must determine to comply with code and satisfy any requirements established for full load sizing.

$$\text{Actual HP Sizing} = QH\ @\ T_{des} / BHL \quad \neq \quad \text{HP Sizing Parameter}$$

Coefficients for Seasonal Heating Efficiency: $COP_{season,ee} = a + b \times HSPF/3.412$

Scenario	Albany		Binghamton		Buffalo		Massena		New York		Poughkeepsie		Syracuse	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1a														
1b	-0.010	0.880	0.113	0.854	0.219	0.842	-0.185	0.838	0.817	0.781	0.333	0.796	0.124	0.860
1c														
1d	-0.117	0.902	-0.003	0.879	0.081	0.876	-0.259	0.847	0.876	0.760	0.237	0.815	-0.007	0.890
2a	2.552	0.197	2.532	0.202	2.645	0.181	2.304	0.204	2.631	0.255	2.620	0.177	2.565	0.195
2b	2.351	0.256	2.419	0.243	2.644	0.188	2.011	0.290	2.401	0.329	2.470	0.228	2.500	0.217
2c	2.441	0.228	2.480	0.224	2.619	0.198	2.358	0.203	2.366	0.342	2.459	0.239	2.550	0.206
2d	2.615	0.113	2.637	0.113	2.702	0.108	2.312	0.150	3.002	0.105	2.725	0.104	2.655	0.107
2e	2.574	0.125	2.601	0.124	2.647	0.122	2.335	0.143	2.946	0.122	2.654	0.119	2.631	0.116
2f	2.458	0.160	2.493	0.155	2.546	0.153	2.322	0.145	2.888	0.141	2.588	0.135	2.513	0.154
2g	2.351	0.172	2.382	0.169	2.440	0.161	2.125	0.178	2.836	0.134	2.424	0.162	2.415	0.163
2h	2.336	0.179	2.386	0.169	2.422	0.168	2.030	0.205	2.814	0.146	2.372	0.177	2.414	0.168
3a	-3.334	1.993	-3.307	1.991	-3.485	2.065	-2.938	1.810	-3.593	2.178	-3.093	1.929	-3.339	2.006
3b	-2.683	1.735	-2.637	1.728	-2.720	1.770	-2.004	1.446	-2.914	1.913	-2.306	1.624	-2.710	1.757
3c	-2.823	1.775	-2.783	1.769	-2.832	1.800	-1.991	1.436	-3.094	1.966	-2.395	1.645	-2.861	1.800
4a	-0.333	1.141	-0.305	1.138	-0.251	1.137	-0.852	1.263	0.282	1.070	-0.407	1.194	-0.308	1.140
4b	-0.402	1.155	-0.393	1.160	-0.300	1.147	-0.865	1.261	0.316	1.041	-0.390	1.175	-0.385	1.160
4c	-0.166	1.004	-0.019	0.963	0.018	0.961	-0.234	0.972	0.432	0.924	0.121	0.926	-0.006	0.962
4d	-0.240	1.024	-0.102	0.983	0.027	0.950	-0.321	0.993	0.369	0.940	0.110	0.920	-0.127	1.001

Note that the values for scenarios 1a, 1b and 1c are all the same because of revisions to the controls definitions.

Coefficients for Seasonal Cooling Efficiency: $EER_{season,ee} = c + d \times SEER$

Scenario	Albany		Binghamton		Buffalo		Massena		New York		Poughkeepsie		Syracuse	
	c	d	c	d	c	d	c	d	c	d	c	d	c	d
1a														
1b	-0.540	0.961	0.920	0.914	-1.370	1.035	-0.390	0.936	2.910	0.786	-0.510	0.965	-0.810	0.988
1c														
1d	-0.460	0.946	-0.140	0.966	-1.670	1.041	-0.210	0.916	1.520	0.859	-0.590	0.961	-0.890	0.982
2a	12.330	0.118	11.950	0.116	12.240	0.130	12.360	0.135	11.070	0.165	12.100	0.111	12.180	0.123
2b	11.440	0.208	12.210	0.146	11.010	0.229	10.330	0.273	10.080	0.277	12.130	0.167	11.330	0.210
2c	9.810	0.306	10.940	0.232	9.590	0.302	9.160	0.321	9.440	0.323	10.310	0.282	9.740	0.308
2d	12.330	0.118	11.950	0.116	12.240	0.130	12.360	0.135	11.070	0.165	12.100	0.111	12.180	0.123
2e	11.440	0.208	12.210	0.146	11.010	0.229	10.330	0.273	10.080	0.277	12.130	0.167	11.330	0.210
2f	9.810	0.306	10.940	0.232	9.590	0.302	9.160	0.321	9.440	0.323	10.310	0.282	9.740	0.308
2g	9.400	0.314	9.950	0.300	8.130	0.366	8.500	0.351	8.670	0.353	9.080	0.328	9.080	0.327
2h	8.890	0.336	9.440	0.313	7.960	0.375	8.160	0.364	8.510	0.361	9.130	0.327	9.020	0.332
3a	17.760	-0.189	6.680	0.454	10.960	0.199	18.580	-0.218	11.600	0.196	16.240	-0.105	14.460	-0.008
3b	14.530	0.035	14.100	0.009	15.660	-0.060	11.420	0.204	16.950	-0.122	18.500	-0.205	17.260	-0.147
3c	10.850	0.255	17.070	-0.164	14.630	0.017	13.740	0.066	18.850	-0.246	15.270	-0.009	14.140	0.052
4a	-12.940	1.478	-12.220	1.433	-11.550	1.396	-13.560	1.520	-9.590	1.290	-12.690	1.456	-12.770	1.473
4b	-14.160	1.556	-13.060	1.493	-3.400	0.957	-14.370	1.569	-11.850	1.424	-14.010	1.547	-4.690	1.038
4c	-14.370	1.566	-4.310	1.019	-9.600	1.300	-14.650	1.576	-14.290	1.563	-14.680	1.586	-8.450	1.246
4d	-14.440	1.566	-4.690	1.041	-10.170	1.328	-14.700	1.572	-15.140	1.609	-14.790	1.590	-16.480	1.676

Note that several scenarios are the same since control approach and UR do not apply for cooling (i.e. 1a,1b and 1c are all the same, 2a is the same as 2d, etc.)

<u>Heating Load Factor</u>

Factors in the table below ($F_{load,heating}$) are used to determine the fraction of the annual heating load that is met by the ASHP unit.

Fraction of Heating Load Met by the ASHP ($F_{load,heating}$)							
Scenario	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**New York**	**Poughkeepsie**	**Syracuse**
1a	1.00	1.00	1.00	0.98	0.99	0.97	1.00
1b							
1c							
1d	1.00	1.00	1.00	0.99	1.00	0.98	1.00
2a	0.25	0.25	0.25	0.23	0.24	0.25	0.24
2b	0.39	0.38	0.39	0.37	0.39	0.39	0.38
2c	0.56	0.55	0.56	0.55	0.54	0.54	0.55
2d	0.54	0.53	0.53	0.51	0.54	0.51	0.54
2e	0.74	0.73	0.73	0.71	0.72	0.69	0.74
2f	0.86	0.85	0.85	0.82	0.84	0.81	0.86
2g	0.98	0.97	0.97	0.94	0.97	0.92	0.98
2h	0.99	0.98	0.99	0.95	0.98	0.94	0.99
3a	0.72	0.71	0.70	0.67	0.70	0.67	0.72
3b	0.96	0.94	0.94	0.92	0.95	0.90	0.95
3c	0.97	0.96	0.96	0.94	0.97	0.92	0.98
4a	0.43	0.42	0.43	0.42	0.43	0.43	0.42
4b	0.59	0.58	0.58	0.56	0.55	0.56	0.58
4c	0.97	0.96	0.97	0.94	0.96	0.92	0.98
4d	0.99	0.99	0.99	0.96	0.98	0.95	0.99

Note that the values for scenarios 1a, 1b and 1c are all the same because of revisions to the controls definitions.

<u>Cooling Load Factor</u>

Factors in the table below ($F_{load,cooling}$) are used to determine the fraction of the annual cooling load that is met by the ASHP unit. The cooling sizing is determined using assumptions about the relative size of cooling loads (BCL) and heating loads (BHL) in NY based on climate.

Fraction of Cooling Load Met by the ASHP ($F_{load,cooling}$)							
Scenario	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**New York**	**Poughkeepsie**	**Syracuse**
1a	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1b							
1c							
1d	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2a	0.90	0.79	0.90	0.95	0.91	0.88	0.89
2b	0.99	0.95	0.99	1.00	0.99	0.99	0.99
2c	1.00	0.99	1.00	1.00	1.00	1.00	1.00
2d	0.90	0.79	0.90	0.95	0.91	0.88	0.89
2e	0.99	0.95	0.99	1.00	0.99	0.99	0.99
2f	1.00	0.99	1.00	1.00	1.00	1.00	1.00
2g	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2h	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3a	1.00	0.99	1.00	1.00	1.00	1.00	1.00
3b	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3c	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4a	0.99	0.96	0.99	1.00	0.98	0.99	0.99
4b	1.00	0.99	1.00	1.00	1.00	1.00	1.00
4c	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4d	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note that several scenarios are the same since control approach and UR do not apply for cooling (i.e. 1a,1b and 1c are all the same, 2a is the same as 2d, etc.)

<u>Optional Control Features</u>

All the whole building or full load scenarios in the Whole Building and Displacement Scenarios table above correspond to separate control or default control of the ASHP systems. If the ASHP has optional control features, the control factors (F_{ctrl}) in the table below shall be used (otherwise F_{ctrl} is equal to 1.0 by default for separate control). The control factors increase (or decrease) the heating load met by the heat pump. Integrated control (droop control) brings on the backup heating source but still allows the heat pump to operate with the backup heat. This corresponds to a standard 2-stage thermostat and is the default control for Centrally Ducted systems (so F_{ctrl} = 1.0). Changeover controls switch from the heat pump to the backup heating source when the temperature is below the changeover threshold (design temperature plus 5°F, or T_{des}+5°F). This changeover temperature equates to 20°F in NYC and 3°F in Albany. Changeover controls are typical for dual-fuel central-ducted systems but are also found in other heat pump controls. With changeover control, the control factor is less than 1, indicating that the heating load and savings are reduced.

Control Factors (Fctrl) for Optional Control Features (Fctrl = 1.0 for default controls)

Whole or Full Load Scenarios	HP Sizing Parameter	NYC		Other Cities	
		Integrated Control	Changeover T_{des}+5°F	Integrated Control	Changeover T_{des}+5°F
Centrally Ducted (Scenarios 1a and 1d)	0.9	1.00	0.94	1.00	0.99
	1.0	1.00	0.93	1.00	0.99
Ductless Mini-Spilt (Scenarios 2g and 2h)	0.9	1.03	0.96	1.02	0.98
	1.0	1.02	0.96	1.01	0.99
Ductless Multi-Splits (Scenarios 3b and 3c)	0.9	1.05	0.93	1.05	0.94
	1.0	1.04	0.95	1.03	0.97
Compact Ducted Scenarios 4c and 4d)	0.9	1.04	0.99	1.03	0.97
	1.0	1.02	0.94	1.01	0.97

Operating Hours

The Building Equivalent Full Load Hours for heating ($BEFLH_{heating}$) and for cooling ($BEFLH_{cooling}$) in the tables below represent equivalent full load operating hours for HVAC equipment based on EnergyPlus models for 12 commercial building types and 3 multi-family building types. These existing building models were developed by NREL, and run for three weather locations: NY JFK (zone 4A), Buffalo (zone 5A) and Massena (zone 6A).[149]

Commercial and High-Rise Multi-Family $BEFLH_{cooling}$ by City

Building	Buffalo	Massena	NYC
High Rise Multifamily - Pre-war - uninsulated brick	752	573	1,141
High Rise Multifamily - Prior to 1979	693	494	965
High Rise Multifamily - From 1979 Through 2006	738	523	1,007
High Rise Multifamily - From 2007 Through the Present	638	697	1,192
Assembly	803	670	1,080
Auto Repair	778	641	1,186
Big Box Retail	440	363	705
Fast Food Restaurant	547	417	788
Full Service Restaurant	547	417	788
Grocery	343	263	622

[149] Detailed descriptions of these models are found in the white paper *Developing Building Equivalent Full Load Hour (BEFLH) Values for Commercial and Multi-Family Buildings in NYS*, Tables 1, 2 and 3, and the associated narrative.

Building	Buffalo	Massena	NYC
Light Industrial	93	77	230
Motel	1,958	1,760	2,141
Primary School	394	323	632
Religious Worship	307	329	451
Small Office	778	641	1,186
Small Retail	440	363	705
Warehouse	93	77	230
Other	440	363	705

Commercial and High-Rise Multi-Family BEFLH $_{heating}$ by City

Building	Buffalo	Massena	NYC
High Rise Multifamily - Pre-war - uninsulated brick	1,793	1,606	1,431
High Rise Multifamily - Prior to 1979	1,625	1,375	1,242
High Rise Multifamily - From 1979 Through 2006	1,563	1,301	1,216
High Rise Multifamily - From 2007 Through the Present	1,391	1,406	1,144
Assembly	1,233	1,442	751
Auto Repair	793	790	537
Big Box Retail	983	970	779
Fast Food Restaurant	1,508	1,386	1,236
Full Service Restaurant	1,508	1,386	1,236
Grocery	1,204	1,130	1,055
Light Industrial	1,159	1,047	876
Motel	1,127	942	916
Primary School	729	709	558
Religious Worship	1,218	1,264	899
Small Office	793	790	537
Small Retail	983	970	779
Warehouse	1,159	1,047	876
Other	983	970	779

Example Calculation *(Not to be used as default)*

A central ducted air source heat pump system is installed in a full service restaurant located near NYC. The heat pumps are rated at 20 SEER, 13.4 EER, and 11 HSPF with a total system heating capacity at 5ºF of 200 kBTU/h. The system fully replaces the existing gas fired hot water boiler and existing single package central AC system. The building cooling load is 120 kBTU/h and building heating load is 193 kBTU/h The system includes electric resistance supplemental heat. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = \Bigg(\bigg(BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{SEER_{baseline}} - \frac{1}{EER_{season,ee}}\right) \times BEFLH_{cooling} \times F_{load,cooling}\bigg) + \bigg(BHL \times \frac{1}{1{,}000} \times \left(\frac{F_{ElecHeat}}{COP_{season,baseline}} - \frac{1}{COP_{season,ee}}\right) \times \frac{1}{3.412} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}\bigg) - \bigg(BHL \times \frac{1}{1{,}000} \times F_{ElecHeat,new} \times \frac{1}{3.412} \times BEFLH_{heating} \times \left(1 - F_{load,heating} \times F_{ctrl}\right)\bigg)\Bigg)$$

$$\Delta kW = BCL \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times F_{load,cooling} \times CF$$

$$\Delta MMBtu = BHL \times \frac{1}{1{,}000{,}000} \times \frac{F_{FuelHeat}}{Eff_{baseline}} \times BEFLH_{heating} \times F_{load,heating} \times F_{ctrl}$$

BCL = 120,000, from application
$SEER_{baseline}$ = 14.0, from Electric Cooling and Heating System Baseline Efficiencies table based on equipment type from application
$EER_{seaons,ee}$ = c + d x SEER = 1.52 + 0.859 x 20 = 18.7
$EER_{season,ee}$ equation from Compliance Efficiency section
c and d from Coefficients for Seasonal Cooling Efficiency table based on scenario and location from application. To determine scenario, the HP Sizing Ratio is calculated: $QH_{17,max}$ / BHL= 200/193 = 1.04. Thus c and d correspond to scenario 1d based on application conditions
SEER from application
$BEFLH_{cooling}$ = 788, from Operating Hours section
$F_{load,cooling}$ = 1, from Cooling Load Factor table based on scenario from application
BHL = 193,000, from application
$F_{ElecHeat}$ = 0, from application
$COP_{season,baseline}$ = N/A, from application
$COP_{season,ee}$ = a + b x HSPF x 1/3.412 = 0.824 +0.777 x 11 x 1/3.412 = 3.33
$COP_{season,ee}$ equation from Compliance Efficiency section
a and b from Coefficients for Seasonal Heating Efficiency table based on scenario and location from application
HSPF from application
$BEFLH_{heating}$ = 1,236, from Operating Hours section
$F_{load,heating}$ = 1, from Heating Load Factor table based on scenario from application
F_{ctrl} = 1.0, from application for default control
$F_{ElecHeat,new}$ = 1, from application
$EER_{baseline}$ = 11.8, from Electric Cooling and Heating System Baseline Efficiencies table based on equipment type from application
EER_{ee} = 13.4, from application
CF = 0.8, from Coincidence Factor section
$F_{FuelHeat}$ = 1, from application
$EFF_{baseline}$ = 0.82, from Baseline Efficiencies section based on equipment type and size from application

$$\begin{aligned}\Delta kWh = \Bigg(&\left(120{,}000 \times \frac{1}{1{,}000} \times \left(\frac{1}{14} - \frac{1}{18.7}\right) \times 788 \times 1\right) \\ &+ \left(193{,}000 \times \frac{1}{1{,}000} \times \left(0 - \frac{1}{3.33}\right) \times \frac{1}{3.412} \times 1{,}236 \times 1 \times 1.0\right) \\ &- \left(193{,}000 \times \frac{1}{1{,}000} \times 1 \times \frac{1}{3.412} \times 1{,}236 \times (1 - 1 \times 1.0)\right)\Bigg) \\ &= -19{,}297.72\ kWh\end{aligned}$$

$$\Delta kW = 120{,}000 \times \frac{1}{1{,}000} \times \left(\frac{1}{11.8} - \frac{1}{13.4}\right) \times 1 \times 0.8 = 0.971\ kW$$

$$\Delta MMBtu = 193{,}000 \times \frac{1}{1{,}000{,}000} \times \frac{1}{0.82} \times 1{,}236 \times 1 \times 1.0 = 290.91\ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Record of Revision

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1	10/15/2010
12-17-8	12/31/2017
9-18-4	9/28/2018
2-20-5	2/28/2020
7-20-23	7/31/2020
6-22-18	9/2/2022
3-23-16	3/31/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

ENERGY MANAGEMENT SYSTEM (EMS) - GUEST ROOM

Measure Description

This measure covers the installation of guest room energy management systems that control HVAC units for individual hotel[150] and motel[151] rooms based upon occupancy sensors, passive infrared or key cards that indicate room occupancy. Sensors controlled by a networked front desk system must also have occupancy sensors in each guest room.[152] During unoccupied periods[153], the default setting for controlled units must differ from the operating set point by at least five degrees Fahrenheit or shut the unit fan and heating/cooling off completely. The existing (baseline) HVAC system must be manually controlled within each guest room.

The control system may also be tied into other electric loads, such as lighting and plug loads, to shut them off when occupancy is not sensed, however energy savings of additional equipment is not considered under this measure.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{tons}{unit} \times ESF_{electric}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{tons}{unit} \times DSF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{tons}{unit} \times ESF_{fuel}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of guest rooms with energy management systems installed under the

[150] Hotel: Room entrances and corridors are located on the interior of the building. Corridors are conditioned spaces.
[151] Motel: Room entrances and corridors are located on the exterior of the building. Corridors are not conditioned spaces.
[152] A networked system controlled from the front desk is defined as a system capable of identifying reserved rooms according to a timed schedule and controlling HVAC in each guest room separately as defined by NYC Local Law 91, section C202 General Definitions.
[153] An unoccupied room is defined as a guest room that has been continuously unoccupied for at least 30 minutes, per ECCCNYS 2020, Section C403.7.6.1 Temperature Setpoint Controls.

program

tons/unit = Tons of air conditioning per unit, based on nameplate data
$ESF_{electric}$ = Electric energy savings factor (kWh/ton)
DSF = Demand savings factor (kW/ton)
ESF_{fuel} = Fossil fuel energy savings factor (MMBtu/ton)

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application.
$ESF_{electric}$		Lookup from $ESF_{cooling}$ table below based on location, building type, HVAC type, and instruction of housekeeping staff to manually setback prior to installation of EMS system.
DSF		Lookup from $DSF_{cooling}$ table below based on location, building type, HVAC type, and instruction of housekeeping staff to manually setback prior to installation of EMS system.
ESF_{fuel}		Lookup from $ESF_{heating}$ table below based on location, building type, HVAC type, and instruction of housekeeping staff to manually setback prior to installation of EMS system.

$ESF_{electric}$[154]

kWh/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	502	540	503	601	413	478	513
Motel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	1,570	1,686	1,573	1,876	1,294	1,493	1,602
Motel, PTAC w/ Gas Heating, Housekeeping Setback	44	23	37	25	62	45	37
Motel, PTAC w/ Gas Heating, No Housekeeping Setback	140	74	118	79	197	144	120
Motel, PTHP, Housekeeping Setback	205	205	201	227	185	197	205
Motel, PTHP, No Housekeeping Setback	780	795	769	883	688	748	783
Hotel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	171	132	157	145	197	171	159
Hotel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	315	256	291	280	349	312	297
Hotel, PTAC w/ Gas Heating, Housekeeping Setback	102	54	86	57	144	105	87
Hotel, PTAC w/ Gas Heating, No Housekeeping Setback	167	89	141	94	236	173	143

[154] Deemed savings calculated based on IL TRM Version 11.0 values for Chicago, adjusted by the ratio of NCEI Cooling Degree Day 1991-2020 Normals for each listed NY city and Chicago O'Hare Airport (accessed 03/24/2023). IL TRM deemed savings derived through the simulation of hotel and motel models in EnergyPlus as informed by S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013. This source is not publicly available but is referenced by the IL TRM Version 11.0.

kWh/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Hotel, PTHP, Housekeeping Setback	128	84	112	90	164	130	115
Hotel, PTHP, No Housekeeping Setback	222	151	197	164	278	225	201
Hotel, Central Chilled Water Fan Coil w/ Electric Resistance Heating, Housekeeping Setback	148	120	137	132	164	147	140
Hotel, Central Chilled Water Fan Coil w/ Electric Resistance Heating, No Housekeeping Setback	274	234	257	257	291	270	262
Hotel, Central Chilled Water Fan Coil w/ Gas Heating, Housekeeping Setback	79	42	66	44	111	81	68
Hotel, Central Chilled Water Fan Coil w/ Gas Heating, No Housekeeping Setback	126	67	106	71	178	130	108

DSF[155]

kW/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	0.05	0.03	0.04	0.03	0.07	0.05	0.04
Motel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	0.15	0.08	0.12	0.08	0.21	0.15	0.12
Motel, PTAC w/ Gas Heating, Housekeeping Setback	0.05	0.03	0.04	0.03	0.07	0.05	0.04
Motel, PTAC w/ Gas Heating, No Housekeeping Setback	0.15	0.08	0.12	0.08	0.21	0.15	0.12
Motel, PTHP, Housekeeping Setback	0.05	0.03	0.04	0.03	0.07	0.05	0.04
Motel, PTHP, No Housekeeping Setback	0.15	0.08	0.12	0.08	0.21	0.15	0.12
Hotel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	0.06	0.03	0.05	0.03	0.08	0.06	0.05
Hotel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	0.09	0.05	0.08	0.05	0.13	0.10	0.08
Hotel, PTAC w/ Gas Heating, Housekeeping Setback	0.06	0.03	0.05	0.03	0.08	0.06	0.05
Hotel, PTAC w/ Gas Heating, No Housekeeping Setback	0.09	0.05	0.08	0.05	0.13	0.10	0.08
Hotel, PTHP, Housekeeping Setback	0.06	0.03	0.05	0.03	0.08	0.06	0.05
Hotel, PTHP, No Housekeeping Setback	0.09	0.05	0.08	0.05	0.13	0.10	0.08

[155] Deemed savings calculated based on IL TRM Version 11.0 values for Chicago, adjusted by the ratio of NCEI Cooling Degree Day 1991-2020 Normals for each listed NYS major city as compared to Chicago O'Hare Airport (accessed 03/24/2023). IL TRM deemed savings derived through the simulation of hotel and motel models in EnergyPlus as informed by S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013. This source is not publicly available but is referenced by the IL TRM Version 11.0.

kW/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Hotel, Central Chilled Water Fan Coil w/ Electric Resistance Heating, Housekeeping Setback	0.04	0.02	0.04	0.02	0.06	0.04	0.04
Hotel, Central Chilled Water Fan Coil w/ Electric Resistance Heating, No Housekeeping Setback	0.06	0.03	0.05	0.03	0.08	0.06	0.05
Hotel, Central Chilled Water Fan Coil w/ Gas Heating, Housekeeping Setback	0.04	0.02	0.04	0.02	0.06	0.04	0.04
Hotel, Central Chilled Water Fan Coil w/ Gas Heating, No Housekeeping Setback	0.06	0.03	0.05	0.03	0.08	0.06	0.05

ESF_{fuel}[156]

MMBtu/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTAC w/ Gas Heating, Housekeeping Setback	2.02	2.27	2.05	2.53	1.55	1.90	2.09
Motel, PTAC w/ Gas Heating, No Housekeeping Setback	6.25	7.04	6.36	7.85	4.79	5.89	6.48
Hotel, PTAC w/ Gas Heating, Housekeeping Setback	0.30	0.34	0.31	0.38	0.23	0.29	0.31
Hotel, PTAC w/ Gas Heating, No Housekeeping Setback	0.66	0.74	0.67	0.82	0.50	0.62	0.68
Hotel, Central Chilled Water Fan Coil w/ Gas Heating, Housekeeping Setback	0.30	0.34	0.31	0.38	0.23	0.29	0.31
Hotel, Central Chilled Water Fan Coil w/ Gas Heating, No Housekeeping Setback	0.66	0.74	0.67	0.82	0.50	0.62	0.68

Reference CDD and HDD Climate Normals[157]

Location	Cooling Degree Days (CDD)	Heating Degree Days (HDD)
Albany	721	6,391
Binghamton	383	7,200
Buffalo	607	6,502
Massena	406	8,030
New York City	1,017	4,900
Poughkeepsie	745	6,026
Syracuse	618	6,625

156 Deemed savings calculated based on IL TRM Version 11.0 values for Chicago, adjusted by the ratio of NCEI Heating Degree Day 1991-2020 Normals for each listed NYS major city as compared to Chicago O'Hare Airport (accessed 03/24/2023). IL TRM deemed savings derived through the simulation of hotel and motel models in EnergyPlus as informed by S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013. This source is not publicly available but is referenced by the IL TRM Version 11.0.

157 NOAA National Centers for Environmental Information – NCEI 1991-2020 Climate Normals; Chicago CDD (842) and HDD (6,340) used as reference cities for deemed savings value adjustments.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A. Peak coincidence is embedded into DSF values listed above.

Baseline Efficiencies from which Energy Savings are Calculated

The baseline is a hotel or motel guest room with manual heating/cooling temperature set point, with or without instruction to the housekeeping staff to manually setback the temperature.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a hotel or motel guest room with a guest room energy management system that automatically adjusts room temperature by at least 5 degrees of operating set point based on room occupancy. Occupancy is detected by occupancy sensors or keycard sensors that automate temperature setback. The control system shall be configured to adjust temperature set-points within 30 minutes after the occupants have left the guestroom.[158] Networked front desk-controlled systems must also include occupancy sensors in guest rooms.

Savings are based on the guest room energy management system's ability to automatically adjust the guest room's set temperature or reduce the cycle time of the HVAC unit for various occupancy modes.

Operating Hours

Operating hours assumptions, based on heating and cooling degree days by location, are embedded into the estimated savings listed above.

Example Calculation *(Not to be used as default)*

A guest room EMS is installed in a hotel with 50 units, located near Albany. Each room has a 1 ton PTAC equipped with water coils providing heating from a central gas-fired boiler. Prior to EMS, the housekeeping staff was instructed to setback room temperatures in unoccupied rooms. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times \frac{tons}{unit} \times ESF_{electric}$$

$$\Delta kW = units \times \frac{tons}{unit} \times DSF$$

$$\Delta MMBtu = units \times \frac{tons}{unit} \times ESF_{fuel}$$

units = 50, from application
tons/unit = 1, from application

[158] ECCCNYS 2020, Section C403.7.6.1 Temperature Setpoint Controls.

$ESF_{electric}$ = 102, from $ESF_{cooling}$ table based on location, building type, HVAC type, and instruction of housekeeping staff from application
DSF = 0.06, from $DSF_{cooling}$ table below based on location, building type, HVAC type, and instruction of housekeeping staff from application
ESF_{fuel} = 0.31 from $ESF_{heating}$ table based on location, building type, HVAC type, and instruction of housekeeping staff from application

$$\Delta kWh = 50 \times 1 \times 102 = 5{,}100\ kWh$$

$$\Delta kW = 50 \times 1 \times 0.06 = 3.0\ kW$$

$$\Delta MMBtu = 50 \times 1 \times 0.30 = 15.0\ MMBtu$$

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

Guest room energy management systems may be connected to lighting and plug loads in addition to HVAC systems. Shutting off power to lights and plug loads may provide additional electricity savings. These potential savings are not considered in this measure.

References

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   Available from: https://www1.nyc.gov/assets/buildings/local_laws/ll91of2016.pdf
2. ECCCNYS 2020 Section C403.7.6.1: Temperature Setpoint Controls
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[ce]-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC403
3. 2023 Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 11.0. September 22, 2022 (accessed March 24, 2023).
   Available from: https://www.ilsag.info/wp-content/uploads/IL-TRM-Version-11.0-Volumes-1-4-Compiled-Final.pdf
4. NOAA National Centers for Environmental Information – NCEI 1991-2020 Climate Normals.
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

Record of Revision

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12-18-14	12/28/2018
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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTAT - WI-FI (COMMUNICATING)

Measure Description

This section covers Wi-Fi communicating thermostats without behavioral learning capability applied to small commercial buildings with fossil fuel-fired heat boilers or furnaces, electric heat pumps, air conditioners or electric resistance heating. These communicating thermostats allow set point adjustment via a remote application. To claim cooling savings, HVAC systems must have an air conditioner component or be a heat pump system.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings[159]

$$\Delta kWh = units \times \left\{ (\Delta kWh/unit)_{cooling} + \left[(\Delta MMBtu/unit) \times \frac{Eff_{FuelHeat}}{COP} \times \frac{1{,}000{,}000}{3{,}412} \times F_{ElecHeat} \right] \right\}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(\Delta kWh/unit)_{cooling}}{EFLH_{cooling}} \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times (\Delta MMBtu/unit) \times F_{FuelHeat}$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fossil fuel energy savings
units	= Number of measures installed under the program
$(\Delta kWh/unit)_{cooling}$	= Annual electric cooling savings per unit
(ΔMMBtu/unit)	= Annual fossil fuel savings per unit
$Eff_{FuelHeat}$	= Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)

[159] The $Eff_{FuelHeat}$ and 1,000,000 terms in the equation below are included to convert the evaluated heating savings, which were reported in gas MMBtus, to electric heating savings in kWh for electrically heated buildings. Note that the component of the algorithm containing these terms evaluates to zero for non-electrically heated buildings due to the inclusion of the $F_{ElecHeat}$ term.

$F_{ElecHeat}$ = Electric heating factor; used to account for the presence or absence of an electric or heat pump heating system
$F_{FuelHeat}$ = Fossil fuel heating factor; used to account for the presence or absence of a fossil fuel heating system
$EFLH_{cooling}$ = Cooling equivalent full-load hours
CF = Coincidence factor
3,412 = Conversion factor, one kWh equals 3,412 BTU
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(\Delta kWh/unit)_{cooling}$	104	Annual electric cooling savings per installed thermostat, in kWh.[160]
$(\Delta MMBtu/unit)$	6.6	Annual fossil fuel savings per installed thermostat, in MMBtu.[161]
$Eff_{FuelHeat}$		From application. If unknown, use 0.8.[162]
COP	Heat Pump: 2.4 Electric Resistance: 1.0	Assumed efficiency of electric heating system, based on a COP of 1.0 for electric resistance heating and a minimally code compliant, 3-ton split system HP for heat pumps.[163]
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise, use 0.0.
$EFLH_{cooling}$		From application. If unknown, lookup based on building type and location from Appendix G.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[164]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline efficiency is an HVAC system using fossil fuel and/or electricity to provide space heating and cooling controlled by a non-Wi-Fi communicating programmable thermostat.

[160] Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012, pg. 18.
[161] Ibid. pg. 12.
[162] ECCCNYS 2020, Table C403.3.2(4) and Table C403.3.2(5).
[163] ECCCNYS 2020, Table C403.3.2(2).
[164] *No source specified – update pending availability and review of applicable references.*

Compliance Efficiency from which Incentives are Calculated

The compliance efficiency is an HVAC system using fossil fuel and/or electricity to provide space heating and cooling controlled by a Wi-Fi communicating thermostat without behavioral learning capability.

Operating Hours

HVAC system operating hours are embedded in the deemed savings values associated with Wi-Fi communicating thermostats, which are based on metering results. Equipment cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type and location can be found in Appendix G.

Example Calculation *(Not to be used as default)*

Three wi-fi thermostat are installed in offices in an assembly building located near Albany. The building is gas heated. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

$$\Delta kWh = units \times \left\{(\Delta kWh/unit)_{cooling} + \left[(\Delta MMBtu/unit) \times \frac{Eff_{FuelHeat}}{COP} \times \frac{1{,}000{,}000}{3{,}412} \times F_{ElecHeat}\right]\right\}$$

$$\Delta kW = units \times \frac{(\Delta kWh/unit)_{cooling}}{EFLH_{cooling}} \times CF$$

$$\Delta MMBtu = units \times (\Delta MMBtu/unit) \times F_{FuelHeat}$$

units = 3, from application
$(\Delta kWh/unit)_{cooling}$ =104, from Summary of Variables and Data Sources table
(ΔMMBtu/unit) = 6.6, from Summary of Variables and Data Sources table
COP = N/A, based on heating source from application
$F_{ElecHeat}$ = 0, from Summary of Variables and Data Sources table based on heating source from application
$EFLH_{cooling}$ = 478, from Appendix G based on building type and location from application
$F_{FuelHeat}$ = 1, from Summary of Variables and Data Sources table based on heating source from application
CF = 0.8, from Summary of Variables and Data Sources table

$$\Delta kWh = 3 \times \{104 + [0]\} = 312\ kWh$$

$$\Delta kW = 3 \times \frac{104}{478} \times 0.8 = 0.522\ kW$$

$$\Delta MMBtu = 3 \times 6.6 \times 1 = 19.8\ MMBtu$$

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. Cadmus Group, Inc. (September 2012), *"Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation"*, prepared for The Electric and Gas Program Administrators of Massachusetts.
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Wi-Fi-Programmable-Controllable-Thermostat-Pilot-Program-Evaluation_Part-of-the-Massachusetts-2011-Residential-Retrofit-Low-Income-Program-Area-Study.pdf
2. ECCCNYS 2020 Table C403.3.2(2): Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps, Table C403.3.2(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements and C403.3.2(5) Minimum Efficiency Requirements: Gas- and Oil-Fired Boilers.
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-cecommercial-energy-efficiency

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3-23-18	3/31/2023

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DOMESTIC HOT WATER

HEAT PUMP WATER HEATER (HPWH) – AIR SOURCE

Measure Description

This measure covers the installation of electric storage tank water heaters that use heat pump technology to move heat from the air (in conditioned or unconditioned spaces) to the water storage tank and are designed to heat and store potable water at a thermostatically controlled temperature of less than 180°F. It is not intended for equipment delivering process or space heating hot water. It applies to electric heat pump water heaters with a maximum current rating of 24 amperes at a voltage no greater than 250 volts and with a rated storage tank capacity of 120 gallons or less.[165,166]

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

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

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

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

Peak Coincident Demand Savings

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

[165] ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2, September 2017.
[166] 10 CFR 430.2.

Annual Fossil Fuel Energy Savings

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

where:

ΔkWh = Annual electric energy savings

ΔkW = Peak coincident demand electric savings

ΔMMBtu = Annual fossil fuel energy savings

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

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

units = Number of measures installed under the program

GPD/unit = Gallons per day of delivered hot water per HPWH

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

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

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

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

$_{baseline}$ = Characteristic of baseline condition

$_{ee}$ = Characteristic of energy efficient condition

UEF = Uniform energy factor

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

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

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

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

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

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

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

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

AFUE = Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
(ΔkW/unit) = Deemed peak coincident demand savings per measure
365 = Days in one year
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kWh equals 3,412 BTU
3.412 = Conversion factor, one watt-hour equals 3.412 BTU
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPD/unit	17.2 x # of people / units	Calculated based on number of people served by the system. If unknown, use 46 GPD divided by the number of units installed.[167]
ΔT_{main}	T_{set} - T_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F).
T_{set}	125	Water heater set point temperature (°F).[168]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
F_{eDHW}		Use a value of 1.0 if the water was previously heated with electricity or if it is a new construction home with no gas access. Otherwise, use 0.0.
F_{FFDHW}		Use a value of 1.0 if the water was previously heated directly with fossil fuels or if it is a new construction home with gas access. Otherwise, use 0.0.
$F_{BoilerDHW}$		Use a value of 1.0 if the water was previously heated indirectly with fossil fuels through the boiler system. Otherwise, use 0.0.
$UEF_{baseline}$		Uniform Energy Factor of the baseline condition. See Baseline Efficiencies… section below for details regarding derivation of this input.
UEF_{ee}		Uniform Energy Factor of the energy efficient measure, from application.
F_{derate}		For equipment installed in unconditioned spaces, lookup in Derate Factor table below based on installation location and nearest city. For equipment installed in conditioned spaces, a value of 1.0 shall be used.
F_{Loc}		Use a value of 1.0 if the water heater is installed in a conditioned space. Otherwise, use 0.0.

[167] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, pg. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
[168] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.

Variable	Value	Notes
F_{Cool}		Lookup in HVAC Interactivity table below based on nearest city.
F_{Heat}		Lookup in HVAC Interactivity table below based on nearest city.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fossil fuel heated. Otherwise, use 0.0.
SEER	13	Assumed efficiency of existing air conditioning system, based on a minimally code compliant, 3-ton, split system AC.[169]
HSPF	Heat Pump: 8.2 Electric Resistance: 3.412	Assumed efficiency of electric heating system, based on a COP of 1.0 for electric resistance heating and a minimally code compliant, 3-ton split system HP for heat pumps.[170]
AFUE		From application. If unknown, lookup from Baseline Efficiencies section based on existing equipment type. For new construction/gut rehab or if equipment type is unknown, assume an 80 MBH gas furnace.
(ΔkW/unit)		Deemed Summer Peak Coincident Demand Savings. Use a value of 0.17 if the water was previously heated with electricity in replacement scenarios and if there is no gas service available in new construction/gut rehab scenarios.[171] Otherwise, use -0.17 for an electric penalty.[172]

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

City	Annual average outdoor temperature[174] (°F)	T_{main} (°F)
Albany	49.4	55.4
Binghamton	46.8	52.8
Buffalo	49.1	55.1

[169] ECCCNYS 2020, Table C403.3.2(1).
[170] ECCCNYS 2020, Table C403.3.2(2).
[171] "Field Testing of Pre-Production Prototype Heat Pump Water Heaters" Federal Energy Management Program, DOE/EE-0317, May 2007.
[172] "CT HVAC and Water Heater Process and Impact Evaluation and CT Heat Pump Water Heater Impact Evaluation", West Hill Energy and Computing, Final Report R1614/R1613, July 19, 2018.
[173] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
[174] Average annual outdoor temperatures taken from NCDC 1991-2020 climate normals.

City	Annual average outdoor temperature[174] (°F)	T_{main} (°F)
Massena	45.1	51.1
NYC	54.7	60.7
Poughkeepsie	50.9	56.9
Syracuse	49.0	55.0

Derate Factor

Standard testing conditions for rating of heat pump water heaters require a dry bulb temperature of 67.5°F ± 1°F and a relative humidity of 50% ±2%.[175] The reported efficiency of heat pump water heaters is established at these conditions; however, heat pump efficiency degrades at lower ambient temperatures. The Derate Factor is established to adjust the published efficiency of the qualifying heat pump water heater when the system is installed in semi-conditioned or unconditioned spaces, namely, garages and basements. The values shown below were derived from Table 10 of Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates published by Bonneville Power Administration in 2011[176] and verified via comparison with results from the 2013 NEEA Heat Pump Water Heater Field Study Report.[177] Average values from northwest heating zones 1 (<6,000 HDD), 2 (6,000 – 7,500 HDD) and 3 (>7,500 HDD)[178] from this analysis and comparison were then mapped to representative NY climate regions as shown below.

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

HVAC Interactivity

Because heat pump water heaters operate via the transfer of heat from the ambient air to the water in the storage tank, systems installed in conditioned spaces will interact with the building's HVAC system. The values shown in the table below reflect the percentage of heat extracted from the ambient air by the heat pump that either decreases the building's cooling load (F_{Cool}) or increases the building's heating load (F_{Heat}). These values were derived from Table 12 of Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates published by Bonneville

[175] 10 CFR 430 Subpart B Appendix E.
[176] Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates, Bonneville Power Administration, November 2011.
[177] NEEA Heat Pump Water Heater Field Study Report, Fluid Market Strategies, October 2013.
[178] NW Council Heating/Cooling zone maps.

Power Administration in 2011[179] and key operating assumptions specified therein. Average values from northwest heating zones 1 (<6,000 HDD), 2 (6,000 – 7,500 HDD) and 3 (>7,500 HDD)[180] were then mapped to representative NY climate regions and scaled linearly based on regional HDD and CDD. The HDD and CDD values are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using base 65° F.[181]

City	CDD	F_{Cool}	HDD	F_{Heat}
Albany	721	0.26	6,391	0.70
Binghamton	383	0.17	7,200	0.76
Buffalo	607	0.24	6,502	0.70
Massena	406	0.16	8,030	0.84
Poughkeepsie	1017	0.29	4,900	0.65
NYC	745	0.51	6,026	0.49
Syracuse	618	0.25	6,625	0.70

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

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

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

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

$UEF_{baseline}$ shall be calculated as a function of qualifying equipment tank volume (v_t) per federal standards[182] as shown in the table below, using the qualifying equipment capacity and draw pattern. Draw pattern can be established based on the proposed equipment First Hour Rating (FHR),

[179] Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates, Bonneville Power Administration, November 2011.
[180] NW Council Heating/Cooling zone maps.
[181] HDD/CDD taken from NCEI 1991-2020 climate normals.
[182] 10 CFR 430.32(d).

rated in gallons. See First Hour Rating vs. Draw Pattern table below. If FHR is unknown, a Medium draw pattern should be assumed for equipment with rated storage capacity ≤50 gallons and a High draw pattern should be assumed otherwise.[183]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x v_t)
		Low	0.9254 - (0.0003 x v_t)
		Medium	0.9307 - (0.0002 x v_t)
		High	0.9349 - (0.0001 x v_t)
	> 55 gal and ≤ 120 gal	Very Small	1.9236 - (0.0011 x v_t)
		Low	2.0440 - (0.0011 x v_t)
		Medium	2.1171 - (0.0011 x v_t)
		High	2.2418 - (0.0011 x v_t)
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.3456 – (0.0020 x v_t)
		Low	0.5982 – (0.0019 x v_t)
		Medium	0.6483 – (0.0017 x v_t)
		High	0.6920 – (0.0013 x v_t)
	> 55 gal and ≤ 100 gal	Very Small	0.6470 – (0.0006 x v_t)
		Low	0.7689 – (0.0005 x v_t)
		Medium	0.7897 – (0.0004 x v_t)
		High	0.8072 – (0.0003 x v_t)
Oil-Fired Storage Water Heater	≤ 50 gal	Very Small	0.2509 – (0.0012 x v_t)
		Low	0.5330 – (0.0016 x v_t)
		Medium	0.6078 – (0.0016 x v_t)
		High	0.6815 – (0.0014 x v_t)

*v_t = tank volume in gallons

First Hour Rating vs. Draw Pattern[184]

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

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

[183] Based on review of typical usage bins for AHRI certified residential water heating equipment. (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[184] 10 CFR 429.17.

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[185]

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

The baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[186] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

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

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

[185] 10 CFR 430.32(e).
[186] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5).

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a heat pump water heater meeting minimum performance requirements specified in ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2.[187] Per that specification, heat pump water heaters with ≤55 gallon storage capacity must have a UEF ≥ 2.00 and heat pump water heaters with >55 gallon storage capacity must have UEF ≥2.20.

Operating Hours

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

Example Calculation *(Not to be used as default)*

A 40-gallon heat pump water heater replaces an existing gas-fired storage water heater in a single family detached home located near Albany with 3 residents. The heat pump water heater has a UEF of 3.5 and a first hour rating of 60 gallons per hour. The water heater is installed in the home's conditioned utility closet, and the home's gas heating system has an AFUE of 80%. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

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

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

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

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

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

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

units = 1, from application
GPD/unit = 17.2 x # of residents/1 = 17.2 x 3/1 = 51.6
GPD equation based on Summary of Variables and Data Source table
# of residents from application
ΔT_{main} = T_{set} – T_{main} = 125 – 55.4 = 69.6
T_{set} from Summary of Variables and Data Sources table
T_{main} from Cold Water Inlet Temperature lookup table based on location from application
F_{eDHW} = 0, from Summary of Variable and Data Sources table based on baseline DHW fuel source from application
UEF_{ee} = 3.5, from application
F_{derate} = 1, from Summary of Variable and Data Sources table based on location from application
F_{Loc} = 1, from Summary of Variable and Data Sources based on location from application
F_{cool} = 0.26, from HVAC Interactivity section based on location from application
SEER = 13, from Summary of Variable and Data Sources table
$F_{ElecHeat}$ = 0, from Summary of Variable and Data Sources table based on location from application
HSPF = N/A, from application
(ΔkW/unit) = -0.17, from Summary of Variables and Data Sources table based on existing water heating system fuel from application
F_{FFDHW} = 1, from Summary of Variables and Data Sources table based on existing water heating system from application
$UEF_{baseline}$ = 0.6483 – (0.0017 x vt) = 0.6483 – (0.0017 x 40) = 0.5803
$UEF_{baseline}$ equation lookup from Baseline Efficiencies section based on Product Class from baseline application and Rated Storage Volume and Draw Pattern from compliance equipment from application, where Draw Pattern is determined by the First Hour Rating based on application
vt from application of compliance equipment
$F_{BoilerDHW}$ = 0, from Summary of Variables and Data Sources table based on existing water heating system from application
F_{Heat} = 0.70, from HVAC Interactivity section based on location from application
AFUE = 0.80, from application

$$\Delta kWh_{cooling} = 1 \times \frac{51.6 \times 365 \times 8.33 \times 69.6}{3{,}412} \times \frac{1}{3.5} \times 1 \times \frac{0.26}{13/3.412} = 62.40\ kWh$$

$$\Delta kWh_{heating} = 0$$

$$\Delta kWh = 1 \times \frac{51.6 \times 365 \times 8.33 \times 69.6}{3{,}412} \times \left(0 - \frac{1}{3.5 \times 1}\right) + 62.40 - 0 = -851.97\, kWh$$

$$\Delta kW = 1 \times (-0.17) = -0.17\, kW$$

$$\Delta MMBtu = 1 \times \frac{51.6 \times 365 \times 8.33 \times 69.6}{1{,}000{,}000} \times \left[\frac{1}{0.5803} + 0 - \left(\frac{1}{3.5} \times 1 \times 1 \times \frac{0.7}{0.8}\right)\right] = 16.1\, MMBtu$$

Effective Useful Life (EUL)

See [Appendix P](#).

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-13-3	6/30/2013
11-13-2	11/26/2013
12-17-7	12/31/2017
12-18-3	12/31/2018
2-20-1	2/28/2020
7-21-7	8/30/2021
3-23-19	3/31/2023

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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[188]
	Clothes Dryer (incl. Heat Pump Clothes Dryer)	Residential	14	ENERGY STAR® M&I Scoping Report[189]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[190]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[191]
	Induction Cooktop	Residential	16	DEER 2014 EUL ID: Appl-Elec_Cooking
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[192]
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
	Dehumidifier Recycling	Residential	3	Assumes same RUL as RAC
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef

188 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

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191 Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Chapters 7 and 8. Department of Energy (DOE). January 30, 2015, pg. 2-12. https://www.regulations.gov/document?D=EERE-2014-BT-STD-0036-0002

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Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance Recycling	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr
Building Shell	Air Conditioner – Room (RAC) Cover and Gap Sealer	Residential	3	See note below[193]
	Air Leakage Sealing	Residential	15	GDS[194]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[195]
	Insulation – Opaque Shell	Residential	25	GDS[196]
	Plastic Window Insulation	Residential	1	See Note[197]
	Storm Window	Residential	20	DOE[198]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
	Window - Film	Residential	10	DEER 2014 EUL ID: Glaz-Daylt-WinFilm
Domestic Hot Water (DHW)	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[199]
	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
DHW - Control	Low-Flow – Faucet Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Showerhead	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Thermostatic Shower Valve	Residential	10	UPC[200]

193 Average/typical manufacturer warranty period for AC covers.
194 GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
195 Ibid.
196 Ibid.
197 1 year is assumed to be the EUL since plastic window insulation comes in the form of single-use kits that are disposed of when the heating season ends
198 https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
199 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
200 UPC certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a. A standard that includes a lifecycle test consisting of 10,000 cycles without fail. 10,000 cycles is the equivalent of three users showering daily for more than nine years.

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner – Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
	Air Conditioner – Room (RAC)	Residential	12	GDS[201]
	Air Conditioner – PTAC	Residential	15	DEER 2014 EUL ID: HVAC-PTAC
	Boiler, Hot Water – Steel Water Tube	Residential	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	Residential	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	Residential	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	Residential	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	Residential	30	ASHRAE Handbook, 2015
	Boiler and Furnace - Combination ("Combi") Boiler	Residential	22	DOE[202]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER 2014[203] EUL ID: HVAC-Frnc
	Duct Sealing and Insulation	Residential	18	DEER 2014 EUL ID: HV-DuctSeal
	Electronically Commutated (EC) Motor – HVAC Blower Fan	Residential	15	DEER 2014 EUL ID: Motors-fan
	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	Residential	15	DEER 2014 EUL ID: Motors-pump

[201] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[202] 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
[203] Based on DEER value for high efficiency boiler and instantaneous water heater.

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Energy and Heat Recovery Ventilator	Residential	14	PA Consulting Group[204]
	Furnace, Gas Fired	Residential	22	DOE[205,206]
	Gas Heat Pump	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[207]
	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-Ref-Chrg
	Tune-Up - Boiler	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Tune-Up - Furnace	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Unit Heater, Gas Fired	Residential	13	ASHRAE Handbook, 2015
HVAC - Control	Adaptive Photonic Control	Residential	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A

[204] 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

[205] 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

[206] 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

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
HVAC - Control	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[208]
	Thermostat – All Types	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[209]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[210]
Lighting[211]	LED Lamp	Residential	Rated Life listed by ENERGY STAR® or default to 15,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Lamps[212]
	Light Fixture	Residential LED (Interior)	50,000 hours	DLC[213]
			Residential	Rated Life listed by ENERGY STAR or default to 25,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known

208 NYSERDA Residential Electric Submetering Manual.
209 U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. pg. 16.
210 Based on assumed EUL of integrated fan, which is expected to be the first component to fail.
211 In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard in the V10 NY TRM filing. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4
212 ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, pg. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf
213 Placed on the Qualified Products List by the Design Light Consortium (DLC) 50,000 hours, according to the appropriate Application Category as specified in the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4 or higher.

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting[214]	Light Fixture	LED (Exterior)	Residential	Rated Life listed by ENERGY STAR or default to 35,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Fixtures[215]
		LED (Inseparable)	Residential	Rated Life listed by ENERGY STAR or default to 50,000 hrs/ annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hours are not known	ENERGY STAR® Fixtures
Lighting Control	Bi-Level Lighting		Multifamily Common Area	15	ComEd[216]
	Connected Lighting		Residential	3	GE and Philips Hue Bridge[217]

[214] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard in the V10 NY TRM filing. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4

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

[216] 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

[217] Cync by General Electric Limited Warranty for Smart Bulbs and Light Strips https://www.gelighting.com/smart-home/warranty and Philips End of Support Policy: End of Support Policy | Philips Hue (philips-hue.com)

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Motors and Drives	Pool Pump	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
	Pool Circulator Timer	Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Other	Heat Pump Pool Heater	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Pool Heater	Residential	8	DOE[218]
	Solar Pool Heater	Residential	15	DOE[219]

[218] 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
[219] https://www.energy.gov/energysaver/solar-swimming-pool-heaters

Commercial and Industrial Measures

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment	High Speed Fans	C&I	10	PG&E[220]
	Livestock Waterer	C&I	10	PA Consulting Group[221]
	Milk Pre-Cooler Heat Ex-changer	C&I	15	Ibid
	Refrigeration Heat Recovery	C&I	14	DEER 2014 EUL ID: HVAC-ChlrComp-Ag
	Scroll Compressor	C&I	12	DEER 2014 EUL ID: RefgWrhs-Scroll-Comp
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[222]
	Variable Speed Drive Milk Pump Plate Cooler	C&I	15	PA Consulting Group[223]
	Variable Speed Drive Vacuum Pump	C&I	15	PA Consulting Group[224]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[225]
	Clothes Washer	C&I	11	DEER 2014 EUL ID: Appl-EffCW
	Cooking Equipment[226]	C&I	12	DEER 2014 EUL IDs: Various
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ENERGY STAR®Calc[227]
	Fireplace	C&I	15	DOE[228]
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach

[220] PG&E Work Paper PGE3PAGR117, October 12, 2017.
[221] 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
[222] Based on EUL's for Advanced Power Strips.
[223] 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
[224] 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
[225] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[226] Applicable to all kitchen cooking equipment not otherwise listed.
[227] 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
[228] Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Hearth Products. Chapters 7 and 8. Department of Energy (DOE). January 30, 2015, pg. 2-12. https://www.regulations.gov/document?D=EERE-2014-BT-STD-0036-0002

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Appliance	Induction Cooktop	C&I	16	DEER 2014 EUL ID: Appl-Elec_Cook-ing
	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 Re-cycling	Air Conditioner – Room (RAC)	C&I	3	DEER 2014 EUL ID: HV-RAC-RUL
Building Shell	Air Leakage Sealing	C&I	15	GDS[229]
	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-Cool-Roof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[230]
	Insulation - Opaque Shell	C&I	30	ET & CEC[231]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-Win-Film
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
	Air Curtains	C&I	15	DEER 2014 EUL ID: Motors-fan
Compressed Air	Air Compressor	C&I	13	Other State TRMs[232]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[233]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study[234]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [235]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [236]
	Flow Controller	C&I	13	Other State TRMs [237]
	Low Pressure Drop Filter	C&I	5	Navigant EUL Report [238]

[229] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[230] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[231] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[232] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (December 2018). Estimates range from 10 to 15 years. Cited TRMs are reviewed annually for updates and potential to replace TRM citations with primary reference material.
[233] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission.
[234] 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
[235] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (December 2018). Estimates range from 10 to 15 years. Cited TRMs are reviewed annually for updates and potential to replace TRM citations with primary reference material.
[236] Ibid.
[237] Ibid.
[238] Navigant ComEd Effective Useful Life Research Report. https://www.icc.illinois.gov/docket/P2017-0312/documents/287811/files/501915.pdf

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Domestic Hot Water (DHW)	Heat Pump Water Heater (HPWH)	C&I	10	DEER EUL ID: WtrHt-HtPmp
	Indirect Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Instantaneous Water Heater	C&I	20	DEER 2014 EUL ID: WtrHt-Instant-Com
	Storage Tank Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
DHW - Control	DHW Temperature Turndown	C&I	RUL of DHW System **Default = 5**	N/A
	Drain Water Heat Recovery (DWHR)	C&I	30	2019 Title 24[239]
	Low-Flow – Faucet Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Pre-Rinse Spray Valve (PRSV)	C&I	5	GDS
	Low-Flow – Salon Valve	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Low-Flow – Showerhead	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Central DHW Control	C&I	15	NREL[240]
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[241]
	Boiler and Furnace -Combination (“Combi”) Furnace	C&I	20	DEER 2014[242] EUL ID: HVAC-Frnc
	Boiler, Hot Water – Steel Water Tube	C&I	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	C&I	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015

[239] 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

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

[241] 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

[242] 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 – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: HVAC- ClT-wrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[243]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	Electronically Commutated (EC) Motor - HVAC Blower Fan	C&I	15	DEER 2014 EUL ID: Motors-Fan
	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	C&I	15	DEER 2014 EUL ID: Motors-pump
	Economizer –Dual Enthalpy Air Side	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	Furnace, Gas Fired	C&I	23	DOE[244,245]
	Gas Heat Pump	C&I	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Unitary & Applied	C&I	15	DEER 2014 EUL ID: HVAC-airHP
	Heat Pump – PTHP	C&I	15	DEER 2014 EUL ID: HVAC-PTHP
	Heat Pump – Water Source (WSHP)	C&I	25	ASHRAE[246]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[247]
	Infrared Heater	C&I	17	GDS[248]
	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[249]

[243] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003).
[244] 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
[245] 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
[246] ASHRAE Owning and Operating Cost Database.
Available from: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[247] 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
[248] 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
[249] 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
Heating, Ventilation and Air Conditioning (HVAC)	Tune-Up – Furnace	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Variable Refrigerant Flow (VRF) System	C&I	15	DEER 2014 EUL ID: HVAC-VSD-pump
	Unit Heater, Gas Fired	C&I	13	ASHRAE Handbook, 2015
HVAC – Control	Adaptive Photonic Control	C&I	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Direct Digital Control (DDC) System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Demand Control Ventilation (DCV)	C&I	15	DEER 2014 EUL ID: HVAC-VSD-DCV
	Energy Management System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Energy Management System – Guest Room	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Boiler Economizer	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	GDS[250]
	Kitchen Demand Ventilation Control	C&I	15	PG&E[251]
	Outdoor Temperature Setback Control for Hydronic Boiler	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A
	Steam Trap – Low-Pressure Space Heating	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Steam Trap Monitoring System – Low-Pressure Space Heating	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Thermostat – Programmable Thermostat – Wi-Fi (Communicating)	C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve	C&I	15	DOE[252]
	Advanced Rooftop Control	C&I	EUL = RUL of Existing RTU = RTU EUL – (Current Year – Year of Mfr.) **Default = 5**	N/A

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

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting[253]	Light Fixture	LED Fixture (DLC)	C&I	50,000 hrs /annual lighting operating hrs or 15 yrs if annual operating hrs are not known	DLC[254]
	Light Fixture	LED Fixture (Interior)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hrs/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®[255]
		LED Fixture (Exterior)	C&I	Rated Life listed by ENERGY STAR or default to 35,000 hrs/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®[256]
		LED Fixture (Inseparable)	C&I	Rated Life listed by ENERGY STAR or default to 50,000/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®[257]
		LED Fixture (Uncertified)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hrs /annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	Uncertified

[253] In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard in the V10 NY TRM filing. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4

[254] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4.

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

[256] Ibid.

[257] Ibid.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting[258]	LED Lamp	C&I	50,000 hours	DLC[259]
			Rated Life listed by ENERGY STAR or default to 15,000 hrs /annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®
	LED Open Sign	C&I	16	DEER 2014 EUL ID: LED-sign
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
	Lighting Power Density (LPD)	C&I	15	GDS[260]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[261]
	Integrated Interior Control	C&I	15	ComEd[262]
	Non-Integrated Interior Control	C&I	10	GDS[263]
	Plug-Load Occupancy Sensor	C&I	8	DEER[264]
Motors and Drives	Motor (incl. PEI Pumps)	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Notched & Synchronous Belt	C&I	5	DEER 2014 EUL ID: HV-CoggedBelt
	Pool Pump	C&I	10	DEER 2014 EUL ID: OutD-PoolPump
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSup-Fan
	Elevator Modernization	C&I	15	DEER 2014[265]

258 In response to codification of a 45 lm/W backstop requirement for general service lamps (GSLs), EULs for select lighting measures are currently under review by the TRM Management Committee. Revisions will take effect concurrent with other action taken in response to the imposed GSL standard in the V10 NY TRM filing. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=4

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

260 Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. As directed in the Interior and Exterior Lighting measure, new construction projects may be evaluated based on LPD. This value is provided for use with new construction LPD projects only.
Available from: https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf

261 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

262 Ibid.

263 Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
Available from: https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf

264 DEER value for lighting occupancy sensors.

265 Assumes same EUL as VFD measure.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Other	Heat Pump Pool Heater	C&I	15	DEER 2014 EUL ID: HV-Res HP
	High Efficiency Transformer	C&I	32	DOE[266]
	High Frequency Battery Charger	C&I	15	PG&E[267]
	High Viscosity Industrial Lubricant	C&I	10	ExxonMobil[268]
	Pool Heater	C&I	8	DOE[269]
	Solar Pool Cover	C&I	5	CALMAC[270]
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Steam Trap Monitoring System – Other Applications	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Ozone Laundry	C&I	10	PG&E[271]
	Process Exhaust Filtration	C&I	15	CIBSE[272]
Refrigeration	Air-Cooled Refrigeration Condenser	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Automatic Door Closer for Walk-In Cooler/Freezer	C&I	8	DEER 2014 EUL ID: GrocWlkIn-DrClsr
	Cooler and Freezer Door Gasket	C&I	4	DEER 2014 EUL ID: GrocWlkIn-Strip-Crtn, GrocWlkIn-WDr-Gask
	Cooler and Freezer Door Strip	C&I	4	DEER 2014 EUL ID: GrocWlkIn-Strip-Crtn, GrocWlkIn-WDr-Gask
	EC Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvap-FanMtr
	Equipment (Condenser, Compressor, and Sub-cooling)	C&I	15	DEER 2014 EUL ID: GrocSys-MechSubcl
	Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM)	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvap-FanMtr
	Refrigerated Case Door	C&I	12	DEER 2014 EUL ID: GrocDisp-FixtDoors

266 https://www.federalregister.gov/documents/2019/06/18/2019-12761/energy-conservation-program-energy-conservation-standards-for-distribution-transformers
267 https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf, pg. 43.
268 Information presented in the ExxonMobil study is confidential.
269 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
270 http://www.calmac.org/publications/PoolCoverReport_2015_Final_Report_Appendices.pdf
271 PG&E Work Paper PGECOAPP123, August 22, 2017.
272 Chartered Institution of Building Services Engineers. “Probabilistic Estimation of Service Life.” An industrial ventilation system consists of a fan and a set of filters; Fan and Filter EUL are 15 to 20 years depending on type. http://www.cibse.org/knowledge/cibse-technical-symposium-2011/probabilistic-estimation-of-service-life

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Refrigeration	Refrigerated Case Night Cover	C&I	5	DEER 2014 EUL ID: GrocDisp-DispCvrs
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Condenser Pressure and Temperature Control	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Floating Head Pressure Control	C&I	10	PA Consulting Group [273]

Common References

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

Record of Revision

Record of Revision Number	Issue Date
EUL's originally listed in July 18, 2011 Order	7/18/2011
Additional EUL's posted on web site	Subsequent to 7/18/2011 Order
7-13-28	7/31/2013
6-14-1	6/19/2014
6-14-2	6/19/2014
6-15-4	6/1/2015
6-16-2	6/30/2016
1-17-8	12/31/2016
6-17-16	6/30/2017
9-17-11	9/30/2017
12-17-17	12/31/2017
3-18-21	3/31/2018
6-18-23	6/30/2018
9-18-21	9/30/2018
12-18-17	12/28/2018
3-19-16	3/29/2019
6-19-14	6/30/2019

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

Record of Revision Number	Issue Date
9-19-10	9/30/2019
12-19-17	12/23/2019
3-20-17	3/30/2020
7-20-20	7/31/2020
12-20-12	12/31/2020
3-21-18	3/31/2021
7-21-21	8/30/2021
12-21-25	1/28/2022
6-22-13	9/2/2022
3-23-21	3/31/2023

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APPENDIX Q

PEAK LOAD SHAPE FACTORS

NATURAL GAS

The peak gas definition is based on the program-induced change in the average daily gas flow in which the distribution system, on average, reaches its pumping/consumption capacity such that as the temperature falls lower (or the heating degree days go higher), gas consumption does not increase. Setting the peak gas definition for this condition means that the gas peak is calculated to reflect the decreased cubic feet of natural gas expected to not flow through the distribution system during the 24-hour period as a result of the impacts of the gas energy efficiency program.

NATURAL GAS PEAK SAVINGS DEFINITION

The natural gas peak savings are defined as the number of therms saved during a day, typically a 24 hour weekday period starting at 10:00AM, at a defined average temperature. The table below shows two different peak day conditions and the respective heating degree days (HDDs) for three of the operating territories in New York; 65 HDDs corresponds to an average temperature of 0^{o}F (-17.8^{o}C).[274]

Condition	New York City (KEDNY, Con Ed)	Long Island (KEDLI)	Upstate (NMPC)
TMY3 Coldest Day	51	55	61
Design Day	65	65	75

PEAK-DAY GAS IMPACT CALCULATION METHODOLOGY

Peak Load Shape Factors (PLSFs) are the ratio of energy use on the peak day to energy use for the full year. Consumption PLSFs (CPLSFs) compare peak day consumption to annual consumption while Savings PLSFs (SPLSFs) are determined by dividing measure savings on the peak day by annual measure savings. The measure savings are calculated by subtracting post-retrofit consumption from baseline consumption on both a peak day and annual basis.[275]

Hourly load shapes were developed for each hour of the year (8,760 hours total) for each building segment, operating region, and day type (Design Day and TMY3 Coldest Day). These load shapes leverage the United States Department of Energy (DOE) residential and commercial prototypical models and are categorized by building type and equipment end-use type (i.e., total facility, heating, hot water, and interior equipment). Consumption and Savings PLSFs for the peak day conditions were then calculated.

These PLSFs may be applied to annual savings to determine peak day savings resulting from programs or subprograms using the following equation:

$$\boldsymbol{Peak\ Day\ Impact\ Savings} = \boldsymbol{Peak\ Load\ Shape\ Factor}^{276} \times \boldsymbol{Annual\ Therm\ Savings}$$

[274] TMY3 weather files for LaGuardia, MacArthur, and Syracuse weather stations were used to determine the TMY3 Coldest day for New York City, Long Island, and Upstate New York respectively. The peak HDD for the TMY3 files the coldest 24 hr period starting at 10AM each respective location.
[275] See referenced memos for more details about how different energy efficiency measures were simulated.
[276] Savings or Consumption PLSFs may be used here.

The PLSF value is assigned based on building segment, end-use category, operating region, and day type in the following tables:

PEAK-LOAD SHAPE FACTOR TABLES

The following Tables present PLSFs for different operating companies. Below is a list of acronyms used in the tables:

- Com – Commercial
- DCV – Demand control ventilation
- EMS- Energy management system
- EQ – Equipment
- NYPA – New York Power Authority
- Res – Residential
- WH – Water heater

Con Edison Design Day Gas Savings PLSFs

Building Segment	Boiler EMS	Smart Thermo-stat
Residential	0.0082	0.0070

Con Edison Design Day Gas Consumption PLSFs

Building Segment	Whole Building	Space Heating	Water Heating	Other Inte-rior Equip-ment
Single Family - Res	0.0202	0.0272	0.0033	
Small Multi-Family - Res	0.0202	0.0272	0.0033	
Large Multi-Family - Res	0.0202	0.0272	0.0033	
NYPA - Res	0.0202	0.0272	0.0033	
Large Office	0.0130	0.0131	0.0042	
Small Office	0.0130	0.0131	0.0042	
Restaurant	0.0089	0.0159	0.0034	0.0027
Large Retail	0.0188	0.0188		
Small Retail	0.0192	0.0192		
Grocery	0.0130	0.0138	0.0030	0.0027
Warehouse/Industrial	0.0245	0.0245		
Education	0.0159	0.0164	0.0050	0.0036
Hospital	0.0067	0.0073	0.0035	0.0027
Nursing Home/Lodging	0.0040	0.0090	0.0034	0.0027
Miscellaneous/Entertainment	0.0100	0.0176	0.0033	0.0027
Multi-Family - Common Area	0.0420	0.0420	0.0033	
NYPA – Com	0.0130	0.0131	0.0042	

NMPC Design Day Gas Savings PLSFs

Building	Weatherization	Smart Thermostat	Boiler EMS	DCV	Storage WH	Air Curtains	Heating EQ Upgrades	Instant WH	Steam Traps	EMS
Single Family	0.0115	0.0043					0.0134	0.0030		
Multi Family	0.0111	0.0038	0.0066				0.0180	0.0034	0.0180	
Grocery	0.0165			0.0143						
Hospital	0.0124									
Hotel	0.0135			0.0110						
Miscellaneous	0.0123			0.0138						
Office	0.0166			0.0127	0.0044		0.0287		0.0287	0.0029
Restaurant	0.0168			0.0117						
Retail	0.0128			0.0137	0.0034	0.0139	0.0173		0.0173	0.0106
School	0.0136			0.0509	0.0055		0.0298		0.0298	0.0035
University	0.0140			0.0263						
Warehouse	0.0103									

NMPC Design Day Gas Consumption PLSF

Building	Whole Building	Water Heating	Space Heating	Other Interior Equipment
Single Family	0.0109	0.0031	0.0134	0.0027
Multi Family	0.0123	0.0035	0.0180	
Grocery	0.0123	0.0031	0.0180	0.0027
Hospital	0.0074	0.0027	0.0104	0.0030
Hotel	0.0099	0.0030	0.0234	0.0026
Miscellaneous	0.0127	0.0032	0.0184	0.0033
Office	0.0230	0.0035	0.0287	
Restaurant	0.0070	0.0031	0.0128	0.0027
Retail	0.0141	0.0031	0.0173	0.0033
School	0.0196	0.0053	0.0298	0.0047
University	0.0134	0.0036	0.0191	0.0024
Warehouse	0.0131	0.0031	0.0148	

NMPC TMY3 Coldest Day Gas Savings PLSFs

Building	Weatheri-zation	Smart Ther-mostat	Boiler EMS	DCV	Storage WH	Air Cur-tains	Heating EQ Upgrades	Instant WH	Steam Traps	EMS
Single Family	0.0089	0.0067					0.0107	0.0030		
Multi Family	0.0089	0.0049	0.0059				0.0115	0.0034	0.0115	
Grocery	0.0135			0.0114						
Hospital	0.0095									
Hotel	0.0095			0.0096						
Miscellaneous	0.0099			0.0113						
Office	0.0130			0.0102	0.0044		0.0150		0.0150	0.0042
Restaurant	0.0130			0.0095						
Retail	0.0101			0.0112	0.0034	0.0109	0.0133		0.0133	0.0091
School	0.0110			0.0202	0.0055		0.0186		0.0186	0.0033
University	0.0109			0.0137						
Warehouse	0.0082									

NMPC TMY3 Coldest Day Gas Consumption PLSF

Building	Whole Building	Water Heating	Space Heating	Other Interior Equipment
Single Family	0.0088	0.0030	0.0107	0.0027
Multi Family	0.0084	0.0035	0.0115	
Grocery	0.0097	0.0031	0.0139	0.0027
Hospital	0.0051	0.0027	0.0066	0.0030
Hotel	0.0064	0.0030	0.0132	0.0026
Miscellaneous	0.0100	0.0032	0.0141	0.0033
Office	0.0124	0.0035	0.0150	
Restaurant	0.0059	0.0031	0.0102	0.0027
Retail	0.0110	0.0031	0.0133	0.0033
School	0.0130	0.0053	0.0186	0.0047
University	0.0086	0.0036	0.0117	0.0024
Warehouse	0.0104	0.0031	0.0117	

KEDLI Design Day Gas Savings PLSFs

Building	Weatherization	Smart Thermostat	Boiler EMS	DCV	Storage WH	Air Curtains	Heating EQ Upgrades	Instant WH	Steam Traps	EMS
Single Family	0.0167	0.0086					0.0214	0.0034		
Multi Family	0.0213	0.0063	0.0096				0.0265	0.0026	0.0265	
Grocery	0.0224			0.0185						
Hospital	0.0145									
Hotel	0.0169			0.0139						
Miscellaneous	0.0174			0.0202						
Office	0.0166			0.0127	0.0048		0.0313		0.0313	0.0110
Restaurant	0.0193			0.0143						
Retail	0.0162			0.0200	0.0032	0.0172	0.0247		0.0247	0.0190
School	0.0191			0.0586	0.0059		0.0329		0.0329	0.0058
University	0.0173			0.0298						
Warehouse	0.0227									

KEDLI Design Day Gas Consumption PLSF

Building	Whole Building	Water Heating	Space Heating	Other Interior Equipment
Single Family	0.0157	0.0032	0.0214	0.0027
Multi Family	0.0167	0.0028	0.0265	
Grocery	0.0135	0.0033	0.0224	0.0027
Hospital	0.0056	0.0030	0.0072	0.0030
Hotel	0.0085	0.0037	0.0238	0.0026
Miscellaneous	0.0151	0.0030	0.0272	0.0030
Office	0.0220	0.0037	0.0313	
Restaurant	0.0074	0.0033	0.0158	0.0027
Retail	0.0177	0.0030	0.0247	0.0030
School	0.0184	0.0056	0.0329	0.0049
University	0.0128	0.0037	0.0204	0.0024
Warehouse	0.0267	0.0031	0.0333	

KEDLI TMY3 Coldest Day Gas Savings PLSFs

Building	Weatherization	Smart Ther-mostat	Boiler EMS	DCV	Storage WH	Air Cur-tains	Heating EQ Upgrades	In-stant WH	Steam Traps	EMS
Single Family	0.0137	0.0097					0.0181	0.0034		
Multi Family	0.0180	0.0072	0.0095				0.0212	0.0026	0.0212	
Grocery	0.0181			0.0156						
Hospital	0.0132									
Hotel	0.0129			0.0123						
Miscellaneous	0.0139			0.0175						
Office	0.0139			0.0156	0.0048		0.0210		0.0210	0.0121
Restaurant	0.0156			0.0122						
Retail	0.0133			0.0173	0.0031	0.0143	0.0195		0.0195	0.0298
School	0.0160			0.0417	0.0059		0.0244		0.0244	0.0058
University	0.0147			0.0242						
Warehouse	0.0192									

KEDLI TMY3 Coldest Day Gas Consumption PLSF

Building	Whole Building	Water Heating	Space Heating	Other Interior Equipment
Single Family	0.0134	0.0032	0.0181	0.0027
Multi Family	0.0136	0.0028	0.0212	
Grocery	0.0108	0.0033	0.0174	0.0027
Hospital	0.0050	0.0030	0.0062	0.0030
Hotel	0.0071	0.0037	0.0184	0.0026
Miscellaneous	0.0123	0.0030	0.0216	0.0030
Office	0.0152	0.0037	0.0210	
Restaurant	0.0065	0.0033	0.0132	0.0027
Retail	0.0141	0.0030	0.0195	0.0030
School	0.0143	0.0056	0.0244	0.0049
University	0.0099	0.0037	0.0154	0.0024
Warehouse	0.0214	0.0031	0.0266	

KEDNY Design Day Gas Savings PLSF

Building	Weatherization	Smart Ther-mostat	Boiler EMS	DCV	Storage WH	Air Cur-tains	Heating EQ Upgrades	Instant WH	Steam Traps	EMS
Single Family	0.0212	0.0048					0.0213	0.0033		
Multi Family	0.0221	0.0041	0.0059				0.0296	0.0035	0.0296	
Grocery	0.0276			0.0208						
Hospital	0.0230									
Hotel	0.0189			0.0154						
Miscellane-ous	0.0225			0.0223						
Office	0.0194			0.0172	0.0051		0.0610		0.0610	0.0077
Restaurant	0.0231			0.0159						
Retail	0.0204			0.0218	0.0041	0.0178	0.0293		0.0293	0.0325
School	0.0225			0.0770	0.0059		0.0388		0.0388	0.0060
University	0.0221			0.0386						
Warehouse	0.0215									

KEDNY Design Day Gas Consumption PLSF

Building	Whole Building	Water Heating	Space Heating	Other Interior Equipment
Single Family	0.0154	0.0034	0.0213	0.0027
Multi Family	0.0192	0.0039	0.0296	
Grocery	0.0159	0.0033	0.0289	0.0027
Hospital	0.0097	0.0032	0.0125	0.0030
Hotel	0.0088	0.0037	0.0270	0.0026
Miscellaneous	0.0140	0.0037	0.0311	0.0033
Office	0.0393	0.0037	0.0610	
Restaurant	0.0076	0.0034	0.0177	0.0027
Retail	0.0204	0.0036	0.0293	0.0033
School	0.0214	0.0057	0.0388	0.0078
University	0.0186	0.0039	0.0299	0.0030
Warehouse	0.0285	0.0031	0.0355	

KEDNY TMY3 Coldest Day Gas Savings PLSF

Building	Weatherization	Smart Thermostat	Boiler EMS	DCV	Storage WH	Air Curtains	Heating EQ Upgrades	Instant WH	Steam Traps	EMS
Single Family	0.0165	0.0093					0.0181	0.0033		
Multi Family	0.0183	0.0056	0.0077				0.0227	0.0035	0.0227	
Grocery	0.0204			0.0161						
Hospital	0.0189									
Hotel	0.0134			0.0136						
Miscellaneous	0.0174			0.0178						
Office	0.0181			0.0180	0.0050		0.0410		0.0410	0.0093
Restaurant	0.0172			0.0127						
Retail	0.0151			0.0176	0.0041	0.0130	0.0208		0.0208	0.0349
School	0.0173			0.0491	0.0059		0.0248		0.0248	0.0065
University	0.0181			0.0279						
Warehouse	0.0208									

KEDNY TMY3 Coldest Day Gas Consumption PLSF

Building	Whole Building	Water Heating	Space Heating	Other Interior Equipment
Single Family	0.0132	0.0032	0.0181	0.0027
Multi Family	0.0151	0.0039	0.0227	
Grocery	0.0116	0.0033	0.0205	0.0027
Hospital	0.0084	0.0032	0.0106	0.0030
Hotel	0.0068	0.0037	0.0185	0.0026
Miscellaneous	0.0104	0.0037	0.0218	0.0033
Office	0.0267	0.0037	0.0410	
Restaurant	0.0063	0.0034	0.0136	0.0027
Retail	0.0147	0.0036	0.0208	0.0033
School	0.0150	0.0057	0.0248	0.0078
University	0.0137	0.0039	0.0212	0.0030
Warehouse	0.0245	0.0031	0.0305	

The following tables show calculated gas peak load shape factors for each facility type in each weather city representing NYSEG and RG&E. PLSF's are represented for the whole facility, heating space conditioning, and domestic hot water consumption.[277]

Albany

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Assembly	0.0179	0.0028	0.0161
Auto Repair	0.0057	0.0032	0.0056
Big Box Retail	0.0212	0.003	0.0206
Fast Food	0.0124	0.0029	0.0105
Full Service Restaurant	0.0128	0.0029	0.0111
Grocery	0.0144	0.0024	0.0139
Hotel	0.0085	0.003	0.0049
High School	0.0023	0.0016	0.0022
Hospital	0.0046	0.003	0.0042
Large Office	0.0069	0.0012	0.0068
Low Rise Multi Family	0.0093	0.0033	0.0086
Light Industrial	0.0166	0.0015	0.0152
Multi Family High Rise	0.0145	0.0032	0.0111
Elementary	0.0144	0.0017	0.0137
Religious	0.0072	0.0017	0.007
Single Family Residential	0.0137	0.0032	0.0076
Small Retail	0.0166	0.003	0.0159
Small Office	0.0159	0.002	0.0134
Warehouse	0.0253	-	0.0253

Binghamton

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Assembly	0.0155	0.0032	0.014
Auto Repair	0.0055	0.0031	0.0053
Big Box Retail	0.0233	0.0029	0.0226
Fast Food	0.0113	0.003	0.0096
Full Service Restaurant	0.0156	0.0032	0.0141
Grocery	0.0117	0.003	0.0113
Hotel	0.0074	0.0031	0.0044
High School	0.0083	0.0052	0.0079
Hospital	0.0044	0.003	0.0041
Large Office	0.0063	0.004	0.0063
Low Rise Multi Family	0.0074	0.0033	0.007
Light Industrial	0.0125	0.0042	0.0117
Multi Family High Rise	0.0105	0.0032	0.0084

277 ADM Associates, Inc., Natural Gas Peak Load Shape Factor Study prepared for Avangrid, January 2023

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Elementary	0.0105	0.0051	0.0102
Religious	0.0066	0.0016	0.0064
Single Family Residential	0.0114	0.0032	0.0067
Small Retail	0.0142	0.0029	0.0137
Small Office	0.014	0.0035	0.012
Warehouse	0.0205	-	0.0205

Buffalo

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Assembly	0.0174	0.0033	0.0157
Auto Repair	0.0057	0.0032	0.0055
Big Box Retail	0.0309	0.003	0.0298
Fast Food	0.0123	0.0031	0.0104
Full Service Restaurant	0.0126	0.003	0.0108
Grocery	0.013	0.0032	0.0125
Hotel	0.0093	0.0032	0.0052
High School	0.0096	0.0054	0.0091
Hospital	0.0052	0.0031	0.0047
Large Office	0.0072	0.0041	0.0071
Low Rise Multi Family	0.0101	0.0034	0.0094
Light Industrial	0.0161	0.0043	0.015
Multi Family High Rise	0.0161	0.0033	0.0126
Elementary	0.013	0.0053	0.0126
Religious	0.0069	0.0017	0.0067
Single Family Residential	0.0147	0.0033	0.0082
Small Retail	0.0175	0.003	0.0168
Small Office	0.0187	0.0036	0.0158
Warehouse	0.0219	-	0.0219

Massena

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Assembly	0.0143	0.0032	0.0132
Auto Repair	0.0053	0.0032	0.0051
Big Box Retail	0.0204	0.003	0.02
Fast Food	0.0105	0.003	0.0092
Full Service Restaurant	0.0105	0.0029	0.0093
Grocery	0.0115	0.0032	0.0111
Hotel	0.0081	0.0031	0.0049
High School	0.0083	0.0051	0.008
Hospital	0.0047	0.003	0.0043
Large Office	0.0061	0.004	0.0061

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Low Rise Multi Family	0.0082	0.0033	0.0076
Light Industrial	0.012	0.0042	0.0114
Multi Family High Rise	0.0123	0.0032	0.0098
Elementary	0.0105	0.0051	0.0103
Religious	0.0067	0.0017	0.0066
Single Family Residential	0.0121	0.0032	0.0073
Small Retail	0.0138	0.0029	0.0133
Small Office	0.0147	0.0036	0.0129
Warehouse	0.0197	-	0.0197

Poughkeepsie

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Assembly	0.0175	0.0026	0.0155
Auto Repair	0.0071	0.0031	0.0069
Big Box Retail	0.0235	0.0029	0.0226
Fast Food	0.0159	0.003	0.0127
Full Service Restaurant	0.0172	0.0028	0.0141
Grocery	0.0148	0.0025	0.0141
Hotel	0.0077	0.0031	0.0046
High School	0.006	0.0014	0.0055
Hospital	0.0042	0.003	0.004
Large Office	0.007	0.001	0.0069
Low Rise Multi Family	0.0121	0.0033	0.0109
Light Industrial	0.0194	0.0004	0.0172
Multi Family High Rise	0.0223	0.0032	0.0147
Elementary	0.0158	0.0015	0.0149
Religious	0.0107	0.0038	0.0104
Single Family Residential	0.0164	0.0032	0.0081
Small Retail	0.0195	0.0031	0.0183
Small Office	0.0219	0.0017	0.0171
Warehouse	0.0248	-	0.0248

Syracuse

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
Assembly	0.0186	0.003	0.0167
Auto Repair	0.0058	0.0032	0.0057
Big Box Retail	0.0299	0.0029	0.0289
Fast Food	0.0132	0.003	0.0111
Full Service Restaurant	0.0135	0.0029	0.0116
Grocery	0.0127	0.003	0.0122
Hotel	0.0087	0.0031	0.005

Building Type	Heat PLSF	Water PLSF	Total End Use PLSF
High School	0.0084	0.0051	0.008
Hospital	0.0049	0.003	0.0045
Large Office	0.0064	0.004	0.0064
Low Rise Multi Family	0.0093	0.0033	0.0087
Light Industrial	0.0149	0.0042	0.0138
Multi Family High Rise	0.0143	0.0032	0.0109
Elementary	0.0127	0.005	0.0123
Religious	0.0072	0.0017	0.007
Single Family Residential	0.0138	0.0032	0.0076
Small Retail	0.0171	0.0029	0.0164
Small Office	0.0166	0.0035	0.0139
Warehouse	0.0214	-	0.0214

APPLICATION GUIDANCE

1. Users must determine the appropriate mapping from the building types presented here to the building types to which the PLSFs are being applied, particularly for Commercial building types. To the extent that a building type and / or measure is not directly mentioned in the PLSF Tables, users should choose the building type / measure type that most closely represents the consumption or savings profile of the gas consumption to which the PLSFs will be applied. The Table below provides some general guidance on this mapping exercise:

Peak Load Shape Factor	Examples of Measure Categories	Buildings Simulated
Whole Building CPLSF	Custom	All
Space Heating CPLSF	Heating system efficiency improvements for buildings	All
Water Heating CPLSF	Instantaneous water heaters in commercial buildings, storage water heaters in residential buildings	All
Other Interior Equipment CPLSF	Cooking equipment efficiency upgrades, process improvements	All except MF, Office, and Warehouse
Weatherization SPLSF	Window improvements, insulation, air Sealing	All
Smart Thermostat SPLSF	Smart thermostat installations in residential buildings	SF, MF
Boiler EMS SPLSF	Boiler EMS	MF
DCV SPLSF	Ventilation improvements, DCV controls	Grocery, Hotel, Misc., Office, Restaurant, Retail, School, University
Storage WH SPLSF	Storage water heating efficiency improvements,	Retail, School, Office
Air Curtains SPLSF	Air curtains	Retail
Heating EQ Upgrades SPLSF	Heating system efficiency improvements	SF, MF, Retail, School, Office
Instant WH SPLSF	Instantaneous water heater installations, aerators,	SF, MF
Steam Traps SPLSF	Steam traps efficiency improvements	MF, Retail, School, Office
Commercial EMS SPLSF	Commercial EMS implementation, commercial thermostat improvements	Retail, School, Office

2. In using the PLSFs, users should consider whether the application requires TMY3 Coldest Day PLSFs, Design Day PLSFs, or a separate attribute. Typically, for planning purposes which are focused on the Design Day, the Design Day PLSFs would be applicable. However, since Design Day conditions are seldom reached, TMY3 Coldest Day or some intermediate value of PLSF may be appropriate for applications which seek to estimate additional typical peak day impacts.

3. Adjustment for Wholesale Level. The PLSFs generated through this building simulation effort estimate the peak day savings at the retail level. In order to report savings at the wholesale level, an adjustment needs to be made for gas losses.

$$Design\ Day\ Savings = \frac{Annual\ Savings\ x\ PLSF}{(1 - gas\ loss\ rate\ \%)}$$

   The denominator of the equation adjusts retail to wholesale savings. It may be based on lost and unaccounted for gas (LAUF), with an assumption of how much losses contribute to LAUF. A rough estimate of the gas loss factor, based on National Grid data, is 1.3%.

   Please note, this value of the gas loss adjustment is something that should be further explored by users. The rough estimate is based on the difference between the billing data and city-gate deliveries which are collected at a monthly level of granularity. The LAUF may be significantly different on the design day, as factors such as cold temperatures and higher demand may lead to more unaccounted-for gas.

References

1. (Con Ed) Gas Peak Day Analysis Memo - May 23, 2019.
   Available from: http://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=264172&MatterSeq=48457
2. (National Grid) National Grid NY Building Simulation and Metering Study: Gas Peak Day Factor Analysis.
   Available from: https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={534E9E3A-6AF7-49DB-8534-088CDB897F6D}
3. (NYSEG/RGE) ADM Associates, Inc., Natural Gas Peak Load Shape Factor Study prepared for Avangrid, January 2023

Record of Revision

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