Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-23-1	R	7/14/2023	1/1/2024	R/MF Building Shell – Insulation – Opaque Shell	Added content to expand application to floor and rim joist insulation; included provisions for derating existing insulation R-values	Pg.92
6-23-4	R	7/14/2023	1/1/2024	R/MF HVAC – Energy and Heat Recovery Ventilator	Updated method to simplify algorithms and incorporate average temperature and enthalpy values based on bin analysis	Pg.222
6-23-7	R	7/14/2023	1/1/2024	R/MF HVAC – Control – Thermostat – Wi-Fi (Communicating)	Updated reference link	Pg.318
6-23-8	R	7/14/2023	1/1/2024	R/MF Lighting – Interior and Exterior Lighting	Added EUL guidance based specific implementation scenario and prescribed baseline (e.g., LMI vs. Market Rate, Mid/Upstream vs. Downstream)	Pg.336
6-23-11	R	7/14/2023	1/1/2024	C/I HVAC – Energy and Heat Recovery Ventilator	Updated method to simplify algorithms and incorporate average temperature and enthalpy values based on bin analysis	Pg.710
6-23-12	R	7/14/2023	1/1/2024	C/I HVAC – Control – Energy Management System (EMS) – Guest Room	Simplified method to align with PNNL study	Pg.828
6-23-13	R	7/14/2023	1/1/2024	C/I HVAC – Control – Thermostat – Wi-Fi (Communicating)	Updated reference link and removed restriction on learning capability	Pg.851
6-23-16	R	7/14/2023	1/1/2024	Appendix P (EUL)	Updated EULs for measures included in this ROR	Pg.1355

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between April 1, 2023 – July 14, 2023.

BUILDING SHELL

INSULATION - OPAQUE SHELL

Measure Description

This measure covers the installation of wall, ceiling, rim joist, and/or floor insulation to reduce the thermal conductance of the building envelope. Energy and demand savings are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured or estimated to evaluate energy savings. This measure is only applicable to insulation of surfaces separating conditioned spaces from unconditioned spaces or the exterior of the building. Ceiling insulation is applicable to surfaces between the top conditioned floor and the roof. Insulation of a shared wall between two conditioned spaces or the floor/ceiling separating conditioned spaces is not eligible.

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

This measure is only applicable as a retrofit in existing single and multi-family buildings. This measure is not eligible for projects entailing alterations that trigger code. In those cases, more stringent code provisions would serve as baseline, limiting potential incremental savings.

For applications involving insulation of multiple building envelope components (e.g., wall and ceiling), evaluate each component separately via the method below and sum together to determine total estimated energy savings.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

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

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

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh_{cooling}}{EFLH_{cooling}} \times CF$$

Annual Fossil Fuel Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
$R_{baseline}$		From application. If unknown, follow guidance provided in Baseline Efficiency section. Assume default for uninsulated surfaces to be R-2 for floors / ceilings and R-4 for walls / rim joists, per the pre-war uninsulated brick vintage values in the table below.
ΔR		From application.
A		From application.
$F_{framing}$	Walls: 0.25 Ceilings: 0.07 Rim Joists: 0.05 Floors: 0.12	ASHRAE.[1]
$F_{ElecCool}$		If an electric cooling system is present, set equal to 1. Otherwise, set equal to 0.
CDD		Lookup based on location in Heating and Cooling Degree Days table below.
HDD		Lookup based on location in Heating and Cooling Degree Days table below.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
$F_{FuelHeat}$		Use a value of 1.0 if the building is fuel heated. Otherwise, use 0.0.
SEER		From application. Use SEER2 rating if equipment has a SEER2 rating. If unknown use 13 SEER, assuming a minimally code compliant, 3-ton, split system AC.[2]
HSPF		From application. For equipment rated in HSPF2, HSPF2 rating shall be used. If unknown use 8.2 HSPF, assuming a 3-ton central ASHP system.[3] 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.
$Eff_{FuelHeat}$		From application. If unknown, lookup based on system size and type in Baseline Efficiencies from which Energy Savings are Calculated section below.
$EFLH_{cooling}$		Lookup based on building type, vintage and location from Appendix G.
CF	0.69	

[1] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.
[2] ECCCNYS 2020, Table C403.3.2(1)).
[3] Ibid.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[4]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a building envelope with insufficient insulation (i.e., not compliant with all applicable construction code requirements). R-value of existing insulation shall come from application. Because efficacy of insulation is known to degrade over time, R-value adjustment factors are provided in the Insulation Derating Allowances table below. The appropriate value shall be determined based on visual inspection of the quality of existing insulation. If existing insulation cannot be visually inspected, an Insulation Quality of "Good" shall be assumed.

Insulation Derating Allowances[5]

Insulation Quality	Derate Factor
Good	0.82
Fair	0.60
Poor	0.23

In the case of removal of existing insulation, $R_{baseline}$ shall be set equal to the estimated existing insulation R-value while $R_{baseline} + \Delta R$ should be set equal to the sum of the new insulation R-value and the R-value of an uninsulated surface (i.e., R-2 for floors / ceilings, R-4 for walls / rim joists).

If existing insulation R-value is unknown, lookup in the Existing Building Envelope R-value: Walls and Ceilings table below based on building vintage and envelope component for walls and ceilings and in the Existing Building Envelope R-value: Floors and Rim Joists table below based on location and envelope component for floor and rim joist insulation. As an alternative to the defaults presented in the tables below, R-3.1 per inch of existing insulation may be applied.[6]

Existing Building Envelope R-value: Walls and Ceilings

Vintage	Wall	Ceiling
Pre-war uninsulated brick[7]	4	2
Prior to 1979[8]	7	11

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

[5] Values taken from U.S DOE Home Energy Score Insulation Derate Calculator (https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Assessor%20Calculator%20v.020619.xlsx)

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

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

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

Vintage	Wall	Ceiling
From 1979 through 2006[9]	11	19
From 2007 through the present[10]	19	38 (Climate Zones 4 & 5) 49 (Climate Zone 6)

Existing Building Envelope R-value: Floors and Rim Joists[11]

Location	Rim Joist	Floor
NYC	10	19
Outside NYC	15	30

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

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[12]

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 the nameplate efficiency of the existing system. If unknown, the baseline efficiency is defined by International Energy Conservation Code[13] 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

[9] Wall insulation assumes wood frame with siding; Fiberglass insulation in 2 by 4 wall per MEC 1980, Ceiling insulation assumes Fiberglass insulation per MEC 1980, as captured in Appendix A of this TRM for Multi-Family Low-Rise.
[10] ECCCNYS 2007 as captured in Appendix A of this TRM for Multi-Family Low-Rise.
[11] IECC Table R402.1.2 Insulation and Fenestration Requirements by Component
[12] 10 CFR 430.32(e).
[13] 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
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec
Warm Air Unit Heaters, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec
Boiler, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential opaque building shell with increased insulation meeting or exceeding applicable construction code requirements. The installed R-value must be captured and included in the program application.

Opaque shell insulation improvements performed under this measure shall be installed such that all altered envelope components comply with all federal, state, local and municipal codes and standards applicable to alterations to existing buildings, including but not limited to Section R503.1 of ECCCNYS 2020[14] requiring all existing ceiling, wall, and floor cavities exposed during construction to be filled with insulation. Thermal envelope components not altered as part of this measure (e.g. continuous insulation in wood-framed buildings) are not required to meet code for compliance.

Operating Hours

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

[14] ECCCNYS 2020, Section R503 Building Thermal Envelope.

Heating and Cooling Degree Days[15]

City	HDD	CDD
Albany	6,391	721
Binghamton	7,200	383
Buffalo	6,502	607
Massena	8,030	406
NYC	4,900	1,017
Poughkeepsie	6,026	745
Syracuse	6,625	618

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

An existing residential customer in a single-family home located near Binghamton with R-12 roof insulation in fair condition, a gas fired warm air furnace with an efficiency of 0.80 AFUE and no cooling system is adding R-20 of blown-in loose fill cellulose insulation in 500 SF of attic space. Annual Electric Energy Savings and Summer Peak Coincident Demand Savings are not applicable. Annual Fossil Fuel Energy Savings are calculated as below.

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

$R_{baseline}$ = 12 x 0.60 = 7.2, from application, adjusted based on Insulation Derating Allowance table from Baseline Efficiency section
ΔR= 20, from application
A = 500 SF, from application
$F_{framing}$ = 0.07, from Summary of Variables and Data Sources table based on application
HDD = 7,200, from Heating Degree Day table based on location from application
$F_{FuelHeat}$ = 1.0, from Summary of Variables and Data Sources table from HVAC system from application
$Eff_{FuelHeat}$ = 0.80 AFUE, from application

$$\Delta MMBtu = \frac{\left(\frac{1}{7.2} - \frac{1}{7.2 + 20}\right) \times 500 \times (1 - 0.07) \times \ 7{,}200 \ \times 24 \times 1.0}{1{,}000{,}000 \times 0.80} = 10.26 \ MMBtu$$

Effective Useful Life (EUL)

See Appendix P.

[15] HDD/CDD taken from NCEI 1991-2020 climate normal using a 65 °F balance point.

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. Rim joist insulation may yield additional savings resulting from improved air sealing between the first floor and an unconditioned basement or crawlspace.

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. Rim joist insulation may yield additional savings resulting from improved air sealing between the first floor and an unconditioned basement or crawlspace.

References

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps.
2. ECCCNYS 2020 Section R402 Building Thermal Envelope.
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[ce]-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC402
3. ECCCNYS 2020 Section R403 Systems.
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-[re]-residential-energy-efficiency#NYSECC2020P1_RE_Ch04_SecR403
4. ECCCNYS 2020 Section R503 Alterations.
   Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-5-re-existing-buildings.
5. Building America House Simulation Protocols, Robert Henderon and Cheryn Engebrecht, National Renewable Energy Laboratory, October 2010.
   Available from: https://www.nrel.gov/docs/fy11osti/49246.pdf
6. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=dfe00d44cfd9ab9ead4019d69702652a&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132
7. ASHRAE, 2001, “Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP),” Table 7.1.
8. NOAA National Centers for Environmental Information – NCEI 1991-2020 Climate Normals.
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
9. DOE, Energy Saver, Insulation Materials.
   Available from: https://www.energy.gov/energysaver/weatherize/insulation/insulation-materials#fiberglass
10. 2018 International Energy Conservation Code (IECC) R402.1.2 Insulation and Fenestration Criteria
    Available from: CHAPTER 4 [RE] RESIDENTIAL ENERGY EFFICIENCY, 2018 International Energy Conservation Code (IECC) | ICC Digital Codes (iccsafe.org)

11. U.S. DOE Home Energy Score for Insulation Deration adjustments.
Available from:
https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Assessor%20Calculator%20v.020619.xlsx

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-25	7/31/2013
7-13-38	7/31/2013
9-18-2	9/28/2018
3-19-2	3/29/2019
12-19-2	12/23/2019
12-20-2	12/31/2020
3-21-5	4/9/2021
7-21-5	8/30/2021
6-23-1	7/14/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

ENERGY AND HEAT RECOVERY VENTILATOR

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.[16] 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:

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

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

$$\Delta kWh_{cooling} = \frac{4.5 \times CFM \times \Delta H \times Eff_{hx,total}}{1{,}000 \times Eff_{ElecCool}} \times \frac{hrs/day}{24} \times F_{ElecCool}$$

$$\Delta kWh_{heating} = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecHeat}} \times hrs/day \times F_{ElecHeat}$$

$$\Delta kWh_{fan} = \left[\left(\frac{CFM}{1{,}000 \times Eff_{fan,baseline}} \times hrs/day\right) - \left(\frac{W_{fan,ee}}{1{,}000}\right)\right] \times 365$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{\Delta kWh_{fan}}{8{,}760} + \frac{\Delta kWh_{cooling}}{EFLH_{cooling}}\right) \times CF$$

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

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000{,}000 \times Eff_{FuelHeat}} \times hrs/day \times F_{FuelHeat}$$

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

Annual Electric Energy Savings

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

$$\Delta kWh_{cooling} = \frac{1.08 \times CFM \times CDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecCool}} \times hrs/day \times F_{ElecCool}$$

$$\Delta kWh_{heating} = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecHeat}} \times hrs/day \times F_{ElecHeat}$$

$$\Delta kWh_{fan} = \left[\left(\frac{CFM}{1{,}000 \times Eff_{fan,baseline}} \times hrs/day\right) - \left(\frac{W_{fan,ee}}{1{,}000}\right)\right] \times 365$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{\Delta kWh_{fan}}{8{,}760} + \frac{kWh_{cooling}}{EFLH_{cooling}}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000{,}000 \times Eff_{FuelHeat}} \times hrs/day \times F_{FuelHeat}$$

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	= Property of the baseline or existing condition
ee	= Property of the efficient condition
heating	= Property of heating season
cooling	= Property of cooling season
fan	= Property of system fan
CFM	= Maximum rated CFM of the proposed ERV/HRV
ΔH	= Product of the difference between outdoor air and return air enthalpies (Btu/lb air) at each outdoor air enthalpy bin and the number of hours at each bin (Btu-h/lb)

$Eff_{hx,total}$ = Total Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[17] or Total Recovery Efficiency rated in accordance with HVI 920[18]

$Eff_{hx,sens}$ = Sensible Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[19] or Sensible Recovery Efficiency rated in accordance with HVI 920[20]

$Eff_{ElecCool}$ = Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (≥65,000 BTU/h)

$Eff_{ElecHeat}$ = 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

$Eff_{FuelHeat}$ = Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)

hrs/day = Average daily run time, in hours, when ERV/HRV is in recovery mode

$F_{ElecCool}$ = Electric cooling factor, used to account for the presence or absence of a central electric cooling system

$F_{ElecHeat}$ = 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

$Eff_{fan,baseline}$ = Base case exhaust fan efficiency (CFM/W)

$W_{fan,ee}$ = Total rated wattage of ERV/HRV fans

HDD = Heating Degree Days. The number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application.

CDD = Cooling Degree Days. The number of degrees that a day's average temperature is above some baseline temperature, which represents the temperature above which buildings need to be cooled. The baseline temperature is typically 65°F, but may vary based on application.

$EFLH_{cooling}$ = Equivalent full-load cooling hours

CF = Coincidence Factor

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[21] in BTU/h-ºF-CFM

24 = Hours in a day

365 = Days in year

[17] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.

[18] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge

[19] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.

[20] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge

[21] 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.

8,760 = Hours in a year
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU
1,000 = Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
CFM		From application.
ΔH		Lookup from Derivation of DH Values using Bin Analysis table below based on location.
$Eff_{hx,total}$		From application. If unknown, refer to ERV/HRV Defaults table below.
$Eff_{hx,sens}$		From application. If unknown, refer to ERV/HRV Defaults table below.
$Eff_{ElecCool}$		From application or use 14 SEER, assuming a 3-ton central ASHP system.[22] For equipment rated in SEER2, SEER2 rating shall be used.
$Eff_{ElecHeat}$		From application or use 8.2 HSPF, assuming a 3-ton central ASHP system.[23] 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.
$Eff_{FuelHeat}$		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.
hrs/day	19.2	See Operating Hours section below.
$F_{ElecCool}$		Use a value of 1.0 if the building has a central electric cooling system. Otherwise, use 0.0.
$F_{ElecHeat}$		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.
$Eff_{fan,baseline}$	2.8 CFM/W	Per IECC.[24]
$W_{fan,ee}$		From application. If unknown, refer to ERV/HRV Defaults table below
HDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table below.
CDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table below.
$EFLH_{cooling}$		Lookup based on building type, vintage and location from Appendix G

[22] 10 CFR 430.32 (c)(1).
[23] Ibid.
[24] IECC 2018 Table R403.6.1

Variable	Value	Notes
CF	0.69	

ERV/HRV Defaults[25]

Residence Type	CFM	$Eff_{hx,sens}$	$Eff_{hx,total}$	$W_{fan,ee}$
Single-family	153	0.73	0.56	52
Multi-family	64	0.67	0.48	38

Derivation of ΔH Values using Bin Analysis

To account for the full benefits of an ERV transferring sensible and latent heat between supply and exhaust airstreams, it is necessary to establish the aggregate enthalpy difference between outside air and return air (i.e., desired indoor air conditions) across the entire cooling season. To accomplish this, a bin analysis was conducted for each standard weather city to determine the number of hours the outside air dry bulb temperature fell within each 5°F bin and the average air enthalpy within each temperature bin. The results were then input into the below algorithm:

$$\Delta H = \sum (H_{OA} - H_{RA}) \times hrs_{bin}$$

where:

ΔH = Product of the difference between outdoor air and return air enthalpies (Btu/lb air) at each outdoor air enthalpy bin and the number of hours at each bin (Btu-h/lb)

H_{OA} = Average enthalpy at the outdoor air dry bulb temperature bin (per the Outdoor Air Temperature & Enthalpy table below)

H_{RA} = Enthalpy of the return air (assumed constant 25.3 Btu/lb based on 70°F and 50% RH indoor air conditions).

hrs_{bin} = Hours during which the outdoor air dry bulb temperature fell within the bin range (per the Bin Hours table below)

The resultant ΔH values for each standard weather city are presented in the table below.

City	ΔH
Albany	7,656
Binghamton	3,973
Buffalo	6,793
Massena	5,165
NYC	14,315
Poughkeepsie	9,599
Syracuse	7,296

[25] Table of ERV/HRV Default Values is based on all available ERV Certified Data from file 'HVIProd_ER.xlsx' published by Home Ventilating Institute (This table lists certified values of 387 models of ERVs. The default values above assume that Single-family residences will install ERVs with Heating CFM > 75 and Multi-family residences will install ERVs with Heating CFM <= 75 cfm. The respective default values represent arithmetic averages of the respective HVI ERV values separated into these two ERV CFM ranges.

Outdoor Air Temperature & Enthalpy[26]

Outdoor air dry bulb temperature bins and corresponding average enthalpy by city across a typical climatological year is presented in the table below.

DB Temperature Range (°F)	Mid-Point (°F)	Albany (Btu/lb)	Binghamton (Btu/lb)	Buffalo (Btu/lb)	Massena (Btu/lb)	NYC (Btu/lb)	Poughkeepsie (Btu/lb)	Syracuse (Btu/lb)
95 to 100	97.5	24.30	24.26	24.26	24.26	24.26	24.26	24.26
90 to 95	92.5	23.06	23.06	23.06	23.06	23.06	23.06	23.06
85 to 90	87.5	21.86	21.86	21.86	21.86	21.86	21.86	21.86
80 to 85	82.5	20.66	20.66	20.66	20.66	33.96	32.91	32.59
75 to 80	77.5	30.88	30.24	30.56	30.69	32.24	30.99	30.84
70 to 75	72.5	28.75	28.65	28.88	28.72	30.54	29.07	28.73
65 to 70	67.5	27.06	26.70	27.08	26.67	27.22	27.27	27.19
60 to 65	62.5	24.27	24.79	24.33	24.82	23.80	24.42	24.53
55 to 60	57.5	21.07	21.60	21.31	21.74	20.81	21.29	21.35
50 to 55	52.5	18.56	18.82	18.76	18.99	18.32	18.72	18.80
45 to 50	47.5	16.28	16.50	16.47	12.88	15.98	16.28	16.52
40 to 45	42.5	14.19	14.36	14.40	14.45	13.90	14.24	14.40
35 to 40	37.5	12.25	12.37	12.50	12.52	11.92	12.14	12.47
30 to 35	32.5	10.37	10.59	10.66	10.68	10.33	10.35	10.55
25 to 30	27.5	8.73	8.85	8.95	8.83	8.85	8.85	8.88
20 to 25	22.5	7.19	7.31	7.43	7.19	6.23	7.32	7.31
15 to 20	17.5	5.77	5.90	5.03	5.68	5.03	5.03	5.90
10 to 15	12.5	3.83	3.83	3.83	4.23	3.83	3.83	3.83
5 to 10	7.5	2.63	2.64	2.64	2.64	2.64	2.64	2.64
0 to 5	2.5	1.43	1.43	1.43	1.43	1.43	1.43	1.43
-5 to 0	-2.5	0.23	0.23	0.23	0.23	0.23	0.23	0.23
-10 to -5	-7.5	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97
-15 to -10	-12.5	-2.17	-2.17	-2.17	-2.17	-2.17	-2.17	-2.17
-20 to -15	-17.5	-3.37	-3.37	-3.37	-3.37	-3.37	-3.37	-3.37
-25 to -20	-22.5	-4.57	-4.57	-4.57	-4.57	-4.57	-4.57	-4.57
-30 to -25	-27.5	-5.77	-5.77	-5.77	-5.77	-5.77	-5.77	-5.77
-35 to -30	-32.5	-6.97	-6.97	-6.97	-6.97	-6.97	-6.97	-6.97
-40 to -35	-37.5	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18

Bin Hours[27]

Number of hours the outdoor air dry bulb temperature falls within each bin range by city across a typical climatological year is presented in the table below.

DB Temperature Range (°F)	Mid-Point (°F)	Albany (hrs)	Binghamton (hrs)	Buffalo (hrs)	Massena (hrs)	NYC (hrs)	Poughkeepsie (hrs)	Syracuse
95 to 100	97.5	0	0	0	0	0	0	0
90 to 95	92.5	0	0	0	0	0	0	0
85 to 90	87.5	0	0	0	0	0	0	0
80 to 85	82.5	124	0	0	0	246	394	42
75 to 80	77.5	556	195	520	483	698	489	619
70 to 75	72.5	608	574	678	489	1115	578	561
65 to 70	67.5	884	776	916	649	780	832	866
60 to 65	62.5	865	1071	859	959	717	876	893
55 to 60	57.5	659	735	622	714	707	663	648

[26] NCEI 1991-2020 Annual/Seasonal Climate Normals.
[27] Ibid.

DB Temperature Range (°F)	Mid-Point (°F)	Albany (hrs)	Binghamton (hrs)	Buffalo (hrs)	Massena (hrs)	NYC (hrs)	Poughkeepsie (hrs)	Syracuse
50 to 55	52.5	624	648	645	615	735	636	623
45 to 50	47.5	617	636	635	584	746	667	630
40 to 45	42.5	621	626	652	582	882	643	626
35 to 40	37.5	675	670	715	550	1197	811	700
30 to 35	32.5	822	730	819	619	858	963	762
25 to 30	27.5	1056	1157	1246	571	79	839	1139
20 to 25	22.5	608	878	453	886	0	369	650
15 to 20	17.5	41	64	0	731	0	0	1
10 to 15	12.5	0	0	0	328	0	0	0

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[28]

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[29]

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[30] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) as shown in the table below.

[28] 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.
[29] 10 CFR 430.32(e).
[30] ECCCNYS 2020, Table C403.3.2(4) & Table C403.3.2(5).

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
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

The equipment is oversized such that it is able to provide necessary ventilation on the design heating day despite having to run in defrost mode more often. The assumption made is that the system is oversized by 25% to achieve this and that this results in an average daily runtime over the course of the year of 19.2 hours/day (80% of 24 hours) to adequately ventilate the home.

Default HDD and CDD are presented in the table below for use in this methodology.

Heating and Cooling Degree Days[31]

City	HDD	CDD
Albany	6,391	721
Binghamton	7,200	383
Buffalo	6,502	607
Massena	8,030	406
NYC	4,900	1,017
Poughkeepsie	6,026	745
Syracuse	6,625	618

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

An ERV delivering 70 CFM is installed in a high-rise multifamily building built in 1970 with an existing ½ hp exhaust fan system of 70% efficiency located near Albany. The ERV has a sensible effectiveness of 88% and total effectiveness of 68%, and operates for 19.2 hours per day. The building is cooled by a central air conditioner with 13 SEER and heated by an 80% thermal efficient gas furnace. The ERV fan has a motor efficiency of 80%, a mechanical efficiency of 65% and a rated wattage of 90W. Annual Electric Energy Savings, Summer Peak Coincident Demand Savings and Annual Fossil Fuel Energy Savings are calculated as below.

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

$$\Delta kWh_{cooling} = \frac{4.5 \times CFM \times \Delta H \times Eff_{hx,total}}{1{,}000 \times Eff_{ElecCool}} \times \frac{hrs/day}{24} \times F_{ElecCool}$$

$$\Delta kWh_{heating} = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecHeat}} \times hrs/day \times F_{ElecHeat}$$

$$\Delta kWh_{fan} = \left[\left(\frac{CFM}{1{,}000 \times Eff_{fan,baseline}} \times hrs/day\right) - \left(\frac{W_{fan,ee}}{1{,}000}\right)\right] \times 365$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{kWh_{fan}}{8{,}760} + \frac{kWh_{cooling}}{EFLH}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000{,}000 \times Eff_{FuelHeat}} \times hrs/day \times F_{FuelHeat}$$

units = 1, from application

[31] HDD/CDD taken from NCEI 1991-2020 climate normal using a 65 °F balance point.

CFM = 70, from application
$Eff_{hx,total}$ = 0.68, from application
ΔH = 7,656, from Derivation of DH Values using Bin Analysis table
Hrs/day = 19.2 hours, from Summary of Variables and Data Sources table
HDD = 6,391, from Operating Hours Section
$Eff_{ElecCool}$ = 13, from application
$F_{ElecCool}$ = 1, from application
$Eff_{fan,baseline}$ = 2.8 CFM/W, from Summary of Variables and Data Sources table
$Eff_{hx,sens}$ = 0.88, from application
$Eff_{ElecHeat}$ = N/A, from application
$W_{fan,ee}$ = 90, from application
$F_{ElecHeat}$ = 0, from application
$EFLH_{cooling}$ = 686, from Appendix G based on building type, vintage and location
CF = 0.69, from Summary of Variables and Data Sources table
$Eff_{FuelHeat}$ = 0.80, from application
$F_{FuelHeat}$ = 1, from application

$$\Delta kWh = 1 \times (100.91 + 0 + 142.35) = 243.26\ kWh$$

$$\Delta kWh_{cooling} = \frac{4.5 \times 70 \times 7656 \times 0.68}{1{,}000 \times 13} \times \frac{19.2}{24} \times 1 = 100.91\ kWh$$

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

$$\Delta kWh_{fan} = \left[\left(\frac{70}{1{,}000 \times 2.8} \times 19.2\right) - \left(\frac{90}{1{,}000}\right)\right] \times 365 = 142.35\ kWh$$

$$\Delta kW = \left(\frac{142.35}{8{,}760} + \frac{100.91}{686}\right) \times 0.69 = 0.11\ kW$$

$$\Delta MMBtu = \frac{1.08 \times 70 \times 6391 \times 0.88}{1{,}000{,}000 \times 0.80} \times 19.2 \times 1 = 10.20\ MMBtu$$

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.
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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. 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
4. AHRI Standard 1060 (I-P), 2018 Standard for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
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5. HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge, February 2020
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   https://hvi.iwrapper.com/HVI_Certification_Program_Policies/Publication_920
6. 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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Record of Revision

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7-20-2	7/31/2020
6-22-5	9/2/2022
3-23-8	3/31/2023
6-23-4	7/14/2023

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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. For thermostats with behavioral learning capabilities, refer to the "Thermostat – Learning" section the Residential HVAC. 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.

This method relies on evaluated savings on a per thermostat basis, so per unit savings are prescribed per thermostat.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings[32]

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

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)

[32] 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 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.[33]
$(\Delta MMBtu/unit)$	6.6	Annual heating energy savings per installed thermostat, in MMBtu.[34]
$Eff_{FuelHeat}$	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.[35]
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, split system for heat pumps.[36]
$F_{ElecHeat}$		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.[37]

[33] Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012, pg. 18.
[34] Ibid. pg. 12.
[35] 10 CFR 430.32(e)(1)(ii) and Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012.
[36] 10 CFR 430.32(c)(1)
[37] 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.

Baseline Efficiencies from which Energy Savings are Calculated

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.

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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.[38, 39] 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.[40] 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.[41,42] 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.[43,44] 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.

[38] The maximum rated wattage varies for modified spectrum lamps.
[39] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 86.
[40] 42 U.S.C. 6295(i)(6)(A)(v).
[41] DOE 82 FR 7276.
[42] DOE 82 FR 7322.
[43] DOE 87 FR 27439.
[44] 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[45]

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[46]

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

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
W	= Rated wattage of lamp and/or fixture (Watts)

[45] 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.

[46] 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.

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. If the existing wattage is not known for an LMI application, use the "Midstream/Upstream Applications for General Service Lamps" subsection below. For detailed definitions, refer to the NOTE in the "Baseline Efficiency" section.
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.[47]
$\Delta kWh_{LMI,Candelabra}$	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.[48] This value shall also be used if the installation location is unknown.

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

Baseline Efficiencies from which Energy Savings are Calculated

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) [49] in market rate applications shall be established

[47] 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℠ Program," March 2007)., EmPCalc Honeywell Narrative 10_04_16 10 AM.

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

[49] DOE 87 FR 27461.

based on a minimum standard efficacy of 45 lumens per watt.[50] 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. [51,52]

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

[50] DOE 87 FR 27439.
[51] DOE 82 FR 7276.
[52] 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.[53] 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

[53] 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 (Candelabra)	< 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

Reflector/Flood Lamps

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

NYS cities other than NYC, Interior

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.[54]

NYS cities other than NYC, Exterior

Hours of operation for exterior lighting is estimated to be 5.7 operating hours per day or 2,081 (5.7 x 365) hours per year. This value is derived from on-site lighting inventories of homes in New York, exclusive of New York City and Westchester County, and refined through a hierarchical model that drew upon loggers installed in Connecticut, Massachusetts, and Rhode Island. [55]

[54] 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.

[55] 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.[56]

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.[57]

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.[58]

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.[59]

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

[56] 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.

[57] 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.

[58] 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.

[59] 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.[60] These values are consistent with those applied in the EmPower 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

[60] 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)

For Downstream Market Rate applications, see Appendix P.

For LMI applications relying on existing conditions to serve as baseline, and for the alternative method presented for LMI applications, use 3.3 years.[61]

For Midstream and Upstream applications relying on a blended baseline, use 10.7 years.[62]

[61] The EUL is established based on the expected ratio of lifetime savings to annual savings. Given an incandescent existing condition (with an assumed 1-year remaining useful life), installation of an LED with a 15-year lifetime and an efficacy ratio of 6:1 for LED vs. incandescent technology, the EUL is established as Lifetime Savings/Annual Savings = ((Annual Savings * 1 Year) + (Annual Savings * 1/6 * 14 Years)) / Annual Savings = 1 + 14/6 = 3.3.
[62] Midstream and Upstream methods use the same approach, but apply a blended weighting, in alignment with the blended baseline weighting. Applying the same weighting as used to establish blended baselines for Midstream and Upstream applications (37% LMI and 63% Market Rate) to assumed downstream market rate and LMI application lifetimes (15 years and 3.3 years, respectively).

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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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
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12-20-13	12/31/2020
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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

ENERGY AND HEAT RECOVERY VENTILATOR

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.[63] 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:

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

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

$$\Delta kWh_{cooling} = \frac{4.5 \times CFM \times \Delta H \times Eff_{hx,total}}{1{,}000 \times Eff_{ElecCool}} \times \frac{hrs/day}{24} \times F_{ElecCool}$$

$$\Delta kWh_{heating} = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecHeat}} \times hrs/day \times F_{ElecHeat}$$

$$\Delta kWh_{fan} = \left[\left(\frac{CFM}{1{,}000 \times Eff_{fan,baseline}} \times \frac{hrs/day}{24}\right) - \left(\frac{W_{fan,ee}}{1{,}000}\right)\right] \times 24 \times days$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{\Delta kWh_{fan}}{8{,}760} + \frac{\Delta kWh_{cooling}}{EFLH_{cooling}}\right) \times CF$$

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

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000{,}000 \times Eff_{FuelHeat}} \times hrs/day \times F_{FuelHeat}$$

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

Annual Electric Energy Savings

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

$$\Delta kWh_{cooling} = \frac{1.08 \times CFM \times CDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecCool}} \times hrs/day \times F_{ElecCool}$$

$$\Delta kWh_{heating} = \frac{1.08 \times CFM \times HDD \times 24 \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecHeat}} \times \frac{hrs/day}{24} \times F_{ElecHeat}$$

$$\Delta kWh_{fan} = \left[\left(\frac{CFM}{1{,}000 \times Eff_{fan,baseline}} \times \frac{hrs/day}{24}\right) - \left(\frac{W_{fan,ee}}{1{,}000}\right)\right] \times 24 \times days$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{\Delta kWh_{fan}}{8{,}760} + \frac{\Delta kWh_{cooling}}{EFLH_{cooling}}\right) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000{,}000 \times Eff_{FuelHeat}} \times hrs/day \times F_{FuelHeat}$$

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	= Property of the baseline or existing condition
ee	= Property of the efficient condition
heating	= Property of heating season
cooling	= Property of cooling season
fan	= Property of system fan
CFM	= Maximum rated CFM of the proposed ERV/HRV

ΔH	= Product of the difference between outdoor air and return air enthalpies (Btu/lb air) at each outdoor air enthalpy bin and the number of hours at each bin (Btu-h/lb)
$Eff_{hx,total}$	= Total Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[64] or Total Recovery Efficiency rated in accordance with HVI 920[65]
$Eff_{hx,sens}$	= Sensible Effectiveness of heat exchanger rated in accordance with AHRI Standard 1060[66] or Sensible Recovery Efficiency rated in accordance with HVI 920[67]
$Eff_{ElecCool}$	= Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (≥65,000 BTU/h)
$Eff_{ElecHeat}$	= 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
$Eff_{FuelHeat}$	= Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)
hrs/day	= Average daily run time, in hours, when ERV/HRV is in recovery mode
$F_{ElecCool}$	= Electric cooling factor, used to account for the presence or absence of a central electric cooling system
$F_{ElecHeat}$	= 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
$Eff_{fan,baseline}$	= Base case exhaust fan efficiency (CFM/W)
$W_{fan,ee}$	= Total rated wattage of ERV/HRV fans
HDD	= Heating Degree Days. The number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application.
CDD	= Cooling Degree Days. The number of degrees that a day's average temperature is above some baseline temperature, which represents the temperature above which buildings need to be cooled. The baseline temperature is typically 65°F, but may vary based on application.
days	= Days per year of facility operation
$EFLH_{cooling}$	= Equivalent full-load cooling hours
CF	= Coincidence Factor
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[68] in BTU/h-ºF-CFM

[64] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
[65] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge
[66] AHRI Standard 1060 for Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
[67] HVI Publication 920 Product Performance Certification Procedure Including Verification and Challenge
[68] 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

24 = Hours in a day
8,760 = Hours in a year
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU
1,000 = Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
CFM		From application.
ΔH		Lookup from Derivation of ΔH Values using Bin Analysis table below based on location.
$Eff_{hx,total}$		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.
$Eff_{ElecHeat}$		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.
$Eff_{FuelHeat}$		From application, E_c, E_t, or AFUE shall be used, based on nameplate rating metric of existing equipment.
hrs/day		From application.
$F_{ElecCool}$		Use a value of 1.0 if the building has a central electric cooling system. Otherwise, use 0.0.
$F_{ElecHeat}$		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.
$Eff_{fan,baseline}$		From application.
$W_{fan,ee}$		From application.
HDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table below.
CDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table below.
days		From application.
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup by city, building type and HVAC type from Appendix G
CF	0.80	

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.

Derivation of ΔH Values using Bin Analysis

To account for the full benefits of an ERV transferring sensible and latent heat between supply and exhaust airstreams, it is necessary to establish the aggregate enthalpy difference between outside air and return air (i.e., desired indoor air conditions) across the entire cooling season. To accomplish this, a bin analysis was conducted for each standard weather city to determine the number of hours the outside air dry bulb temperature fell within each 5°F bin and the average air enthalpy within each temperature bin. The results were then input into the below algorithm:

$$\Delta H = \sum (H_{OA} - H_{RA}) \times hrs_{bin}$$

where:

ΔH = Product of the difference between outdoor air and return air enthalpies (Btu/lb air) at each outdoor air enthalpy bin and the number of hours at each bin (Btu-h/lb)

H_{OA} = Average enthalpy at the outdoor air dry bulb temperature bin (per the Outdoor Air Temperature & Enthalpy table below)

H_{RA} = Enthalpy of the return air (assumed constant 25.3 Btu/lb based on 70°F and 50% RH indoor air conditions).

hrs_{bin} = Hours during which the outdoor air dry bulb temperature fell within the bin range (per the Bin Hours table below)

The resultant ΔH values for each standard weather city are presented in the table below.

City	ΔH
Albany	7,656
Binghamton	3,973
Buffalo	6,793
Massena	5,165
NYC	14,315
Poughkeepsie	9,599
Syracuse	7,296

Outdoor Air Temperature & Enthalpy[69]

Outdoor air dry bulb temperature bins and corresponding average enthalpy by city across a typical climatological year is presented in the table below.

DB Temperature Range (°F)	Mid-Point (°F)	Albany (Btu/lb)	Binghamton (Btu/lb)	Buffalo (Btu/lb)	Massena (Btu/lb)	NYC (Btu/lb)	Poughkeepsie (Btu/lb)	Syracuse (Btu/lb)
95 to 100	97.5	24.30	24.26	24.26	24.26	24.26	24.26	24.26
90 to 95	92.5	23.06	23.06	23.06	23.06	23.06	23.06	23.06
85 to 90	87.5	21.86	21.86	21.86	21.86	21.86	21.86	21.86
80 to 85	82.5	20.66	20.66	20.66	20.66	33.96	32.91	32.59
75 to 80	77.5	30.88	30.24	30.56	30.69	32.24	30.99	30.84
70 to 75	72.5	28.75	28.65	28.88	28.72	30.54	29.07	28.73

[69] NCEI 1991-2020 Annual/Seasonal Climate Normals.

DB Temperature Range (°F)	Mid-Point (°F)	Albany (Btu/lb)	Binghamton (Btu/lb)	Buffalo (Btu/lb)	Massena (Btu/lb)	NYC (Btu/lb)	Poughkeepsie (Btu/lb)	Syracuse (Btu/lb)
65 to 70	67.5	27.06	26.70	27.08	26.67	27.22	27.27	27.19
60 to 65	62.5	24.27	24.79	24.33	24.82	23.80	24.42	24.53
55 to 60	57.5	21.07	21.60	21.31	21.74	20.81	21.29	21.35
50 to 55	52.5	18.56	18.82	18.76	18.99	18.32	18.72	18.80
45 to 50	47.5	16.28	16.50	16.47	12.88	15.98	16.28	16.52
40 to 45	42.5	14.19	14.36	14.40	14.45	13.90	14.24	14.40
35 to 40	37.5	12.25	12.37	12.50	12.52	11.92	12.14	12.47
30 to 35	32.5	10.37	10.59	10.66	10.68	10.33	10.35	10.55
25 to 30	27.5	8.73	8.85	8.95	8.83	8.85	8.85	8.88
20 to 25	22.5	7.19	7.31	7.43	7.19	6.23	7.32	7.31
15 to 20	17.5	5.77	5.90	5.03	5.68	5.03	5.03	5.90
10 to 15	12.5	3.83	3.83	3.83	4.23	3.83	3.83	3.83
5 to 10	7.5	2.63	2.64	2.64	2.64	2.64	2.64	2.64
0 to 5	2.5	1.43	1.43	1.43	1.43	1.43	1.43	1.43
-5 to 0	-2.5	0.23	0.23	0.23	0.23	0.23	0.23	0.23
-10 to -5	-7.5	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97
-15 to -10	-12.5	-2.17	-2.17	-2.17	-2.17	-2.17	-2.17	-2.17
-20 to -15	-17.5	-3.37	-3.37	-3.37	-3.37	-3.37	-3.37	-3.37
-25 to -20	-22.5	-4.57	-4.57	-4.57	-4.57	-4.57	-4.57	-4.57
-30 to -25	-27.5	-5.77	-5.77	-5.77	-5.77	-5.77	-5.77	-5.77
-35 to -30	-32.5	-6.97	-6.97	-6.97	-6.97	-6.97	-6.97	-6.97
-40 to -35	-37.5	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18	-8.18

Bin Hours[70]

Number of hours the outdoor air dry bulb temperature falls within each bin range by city across a typical climatological year is presented in the table below.

DB Temperature Range (°F)	Mid-Point (°F)	Albany (hrs)	Binghamton (hrs)	Buffalo (hrs)	Massena (hrs)	NYC (hrs)	Poughkeepsie (hrs)	Syracuse
95 to 100	97.5	0	0	0	0	0	0	0
90 to 95	92.5	0	0	0	0	0	0	0
85 to 90	87.5	0	0	0	0	0	0	0
80 to 85	82.5	124	0	0	0	246	394	42
75 to 80	77.5	556	195	520	483	698	489	619
70 to 75	72.5	608	574	678	489	1115	578	561
65 to 70	67.5	884	776	916	649	780	832	866
60 to 65	62.5	865	1071	859	959	717	876	893
55 to 60	57.5	659	735	622	714	707	663	648
50 to 55	52.5	624	648	645	615	735	636	623
45 to 50	47.5	617	636	635	584	746	667	630
40 to 45	42.5	621	626	652	582	882	643	626
35 to 40	37.5	675	670	715	550	1197	811	700
30 to 35	32.5	822	730	819	619	858	963	762
25 to 30	27.5	1056	1157	1246	571	79	839	1139
20 to 25	22.5	608	878	453	886	0	369	650
15 to 20	17.5	41	64	0	731	0	0	1
10 to 15	12.5	0	0	0	328	0	0	0

[70] Ibid.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[71]

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

Operating hours per day shall come from application based on actual operating schedule of the ERV/HRV.

Default HDD and CDD are presented in the table below for use in this methodology.

Heating and Cooling Degree Days[72]

City	HDD	CDD
Albany	6,391	721
Binghamton	7,200	383
Buffalo	6,502	607
Massena	8,030	406
NYC	4,900	1,017
Poughkeepsie	6,026	745
Syracuse	6,625	618

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

An ERV delivering 5,000 CFM is installed in a light industrial building in Binghamton that runs 16 hours per day for 330 days per year. The ERV has an existing fan system of 75% efficiency that consumes 50 watts of power. The ERV has a sensible effectiveness of 65% and total effectiveness of 63%. The building is cooled by a central air conditioner with 15 SEER and heated by an 80% thermal efficient gas fired hot water boiler.

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

$$\Delta kWh_{cooling} = \frac{4.5 \times CFM \times \Delta H \times Eff_{hx,total}}{1{,}000 \times Eff_{ElecCool}} \times \frac{hrs/day}{24} \times F_{ElecCool}$$

[71] *No source specified – update pending availability and review of applicable references.*
[72] HDD/CDD taken from NCEI 1991-2020 climate normal using a 65 °F balance point.

$$\Delta kWh_{heating} = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000 \times Eff_{ElecHeat}} \times hrs/day \times F_{ElecHeat}$$

$$\Delta kWh_{fan} = \left[\left(\frac{CFM}{1{,}000 \times Eff_{fan,baseline}} \times \frac{hrs/day}{24}\right) - \left(\frac{W_{fan,ee}}{1{,}000}\right)\right] \times 24 \times days$$

$$\Delta kW = \left(\frac{\Delta kWh_{fan}}{8{,}760} + \frac{\Delta kWh_{cooling}}{EFLH_{cooling}}\right) \times CF$$

$$\Delta MMBtu = \frac{1.08 \times CFM \times HDD \times Eff_{hx,sens}}{1{,}000{,}000 \times Eff_{FuelHeat}} \times hrs/day \times F_{FuelHeat}$$

units = 1, from application
CFM = 5,000, from application
$Eff_{hx,total}$ = 0.65, from application
$Eff_{ElecCool}$ = 15, from application
$Eff_{ElecHeat}$ = 0.80, from application
$Eff_{hx,sens}$ = 0.65, from application
$Eff_{fan,baseline}$ = 0.75, from application
$Eff_{ElecHeat}$ = N/A, from application
$W_{fan,ee}$ = 50 W, from application
$F_{ElecCool}$ = 1, from application
$F_{ElecHeat}$ = 0, from application
$F_{FuelHeat}$ = 1, from application
hrs/day = 16 hours, from application
days = 330 days, from application
HDD = 7,200, from Heating and Cooling Degree Days table
$EFLH_{cooling}$ = 444 hours, from Appendix G based on building type, city and HVAC type
CF = 0.8, from Summary of Variables and Data Sources table

$$\Delta kWh = 1 \times (2{,}503 + 0 + 34{,}804) = 37{,}307\ kWh$$

$$\Delta kWh_{cooling} = \frac{4.5 \times 5{,}000 \times 3{,}973 \times 0.63}{1{,}000 \times 15} \times \frac{16}{24} \times 1 = 2{,}503\ kWh$$

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

$$\Delta kWh_{fan} = \left[\left(\frac{5{,}000}{1{,}000 \times 0.75} \times \frac{16}{24}\right) - \left(\frac{50}{1{,}000}\right)\right] \times 24 \times 330 = 34{,}804 kWh$$

$$\Delta kW = \left(\frac{34{,}804}{8{,}760} + \frac{2{,}503}{444}\right) \times 0.8 = 7.68 kW$$

$$\Delta MMBtu = \frac{1.08 \times 5{,}000 \times 7{,}200 \times 0.65}{1{,}000{,}000 \times 0.80} \times 16 \times 1 = 505.44\ MMBtu$$

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.

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Record of Revision

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7-20-12	7/31/2020
6-22-11	9/2/2022
3-23-15	3/31/2023
6-23-11	7/14/2023

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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 and motel 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.[73] During unoccupied periods[74], 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

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

$$\Delta kWh_{cooling} = \frac{(BTU/h)_{ElecCool}/unit}{1{,}000 \times Eff_{ElecCool}} \times EFLH_{cooling} \times ESF$$

$$\Delta kWh_{heating} = \frac{(BTU/h)_{ElecHeat}/unit}{1{,}000 \times Eff_{ElecHeat}} \times EFLH_{heating} \times ESF$$

Summer Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{(BTU/h)_{ElecCool}/unit}{1{,}000 \times EER} \times ESF \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = units \times \frac{(BTU/h)_{FuelHeat}/unit}{1{,}000{,}000 \times Eff_{FuelHeat}} \times EFLH_{heating} \times ESF$$

[73] 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.

[74] An unoccupied room is defined as a guest room that has been continuously unoccupied for at least 30 minutes.

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of guest rooms with energy management systems installed under the program
$_{cooling}$	= Property of cooling season
$_{heating}$	= Property of heating season
$(BTU/h)_{ElecCool}$/unit	= Nominal cooling capacity of the electric cooling system per guest room
$(BTU/h)_{ElecHeat}$/unit	= Nominal heating capacity of the electric heating system per guest room
$(BTU/h)_{FuelHeat}$/unit	= Nominal heating capacity of the fossil fuel heating system per guest room
$Eff_{ElecCool}$	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (>65,000BTU/h)
$Eff_{ElecHeat}$	= 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
$Eff_{FuelHeat}$	= Efficiency of fossil fuel heating equipment (AFUE, Et, or Ec)
EER	= Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTU/h divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
$EFLH_{heating}$	= Heating equivalent full-load hours
ESF	= Energy savings factor attributable to guest room EMS
CF	= Coincidence factor
1,000	= Conversion factor, one kW equals 1,000 Watts
1,000,000	= Conversion factor one MMBtu is equal to 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(BTU/h)_{ElecCool}$/unit		From application. If no electric cooling system is present, set equal to 0.
$(BTU/h)_{ElecHeat}$/unit		From application. If no electric heating system is present, set equal to 0.
$(BTU/h)_{FuelHeat}$/unit		From application. If no fossil fuel heating system is present, set equal to 0.
$Eff_{ElecCool}$		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.

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 HPSF = COP x 3.412. For equipment rated in HSPF2, HSPF2 rating shall be used.
$Eff_{FuelHeat}$		From application. Ec, Et, or AFUE shall be used, based on nameplate rating metric of existing equipment.
EER		From application. For equipment rated in EER2, EER2 rating shall be used. If unknown, baseline EER is established as follows[75]: $EER = (1.12 \times Eff_{ElecCool}) - (0.02 \times Eff_{ElecCool}^2)$
$EFLH_{cooling}$		From application. If unknown, lookup based on motel/hotel and location from Appendix G in Operating Hours section below.
$EFLH_{heating}$		From application. If unknown, lookup based on motel/hotel and location from Appendix G in Operating Hours section below.
ESF	18.4%	Based on PNNL Demonstration Study. [76]
CF	0.8	

Coincidence Factor (CF)

The prescribed coincidence factor for the coincidence factor is 0.8.[77]

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. 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.

[75] 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

[76] Pacific Northwest National Laboratory (Sullivan, G.P., and J. Blanchard). Guest Room HVAC Occupancy-Based Control Technology Demonstration. p. 1. September 2012

[77] PA Consulting Group. Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0. Section 4.5.7 Rooftop A/C. March 22, 2010. https://focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf

Operating Hours

Operating hours shall reflect equivalent full load hours heating and cooling based on location and type of facility as found in Appendix G.

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

A motel in Buffalo with 100 units is equipped with an Energy Management System. Each room has a 12,000 BTU/h PTAC equipped with water coils providing heating from a central gas-fired boiler with 15 SEER and 0.8 AFUE. 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.

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

$$\Delta kWh_{cooling} = \frac{(BTU/h)_{ElecCool}/unit}{1{,}000 \times Eff_{ElecCool}} \times EFLH_{cooling} \times ESF$$

$$\Delta kWh_{heating} = \frac{(BTU/h)_{ElecHeat}/unit}{1{,}000 \times Eff_{ElecHeat}} \times EFLH_{heating} \times ESF$$

$$\Delta kW = units \times \frac{(BTU/h)_{ElecCool}/unit}{1{,}000 \times EER} \times ESF \times CF$$

$$\Delta MMBtu = units \times \frac{(BTU/h)_{FuelHeat}/unit}{1{,}000{,}000 \times Eff_{FuelHeat}} \times EFLH_{heating} \times ESF$$

units = 100, from application
$(BTU/h)_{ElecCool}$ = 12,000 BTU/h, from application
$(BTU/h)_{FuelHeat}$ = 12,000 BTU/h, from application
$Eff_{ElecCool}$ = 15 SEER, from application
$Eff_{FuelHeat}$ = 0.80 AFUE, from application
EER = (1.12 x 15) – (0.02 x 15^2) = 12.3, from Summary of Variables and Data Sources table
$EFLH_{cooling}$ = 1,318 hours, from Appendix G
$EFLH_{heating}$ = 765 hours, from Appendix G
ESF = 0.184, from Summary of Variables and Data Sources table
CF = 0.8, from Summary of Variables and Data Sources table

$$\Delta kWh = 100 \times (194) = 19{,}400\ kWh$$

$$\Delta kWh_{cooling} = \frac{12{,}000}{1{,}000 \times 15} \times 1{,}318 \times 0.184 = 194\ kWh$$

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

$$\Delta kW = 100 \times \frac{12{,}000}{1{,}000 \times 12.3} \times 0.184 \times 0.8 = 14.36\ kW$$

$$\Delta MMBtu = 100 \times \frac{12{,}000}{1{,}000{,}000 \times 0.8} \times 765 \times 0.184 = 211.14\ MMBtu$$

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

1. Local Laws of the City of New York for the year 2016, No. 91, 403.2.18 Automatic control of HVAC in hotel/motel guest rooms.
   Available from: https://www1.nyc.gov/assets/buildings/local_laws/ll91of2016.pdf
2. NOAA National Centers for Environmental Information – NCEI 1991-2020 Climate Normals.
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
3. Pacific Northwest National Laboratory (Sullivan, G.P., and J. Blanchard). Guest Room HVAC Occupancy-Based Control Technology Demonstration. p. 1. September 2012. Available from: http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/creea_guest_room_occupa ncy-based_controls_report.pdf
4. 2015 International Energy Conservation Code. Table C403.2.3(3). 2015.
   Available from: https://codes.iccsafe.org/public/document/
5. PA Consulting Group. Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0. Section 4.5.7 Rooftop A/C. March 22, 2010.
   Available from:
   https://focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf

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6-23-12	7/14/2023

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTAT - WI-FI (COMMUNICATING)

Measure Description

This section covers Wi-Fi communicating thermostats 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[78]

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

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)
$F_{ElecHeat}$	= 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

[78] 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.

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.[79]
(ΔMMBtu/unit)	6.6	Annual fossil fuel savings per installed thermostat, in MMBtu.[80]
$Eff_{FuelHeat}$		From application. If unknown, use 0.8.[81]
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.[82]
$F_{ElecHeat}$		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.[83]

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.

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.

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

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
$(\Delta MMBtu/unit)$ = 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: https://ma-eeac.org/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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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[84]
	Clothes Dryer (incl. Heat Pump Clothes Dryer)	Residential	14	ENERGY STAR® M&I Scoping Report[85]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[86]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[87]
	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[88]
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

[84] 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

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

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

[87] 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

[88] Retail Products Platform Product Analysis, Last Updated May 25, 2016. Available from: https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance Recycling	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[89]
	Air Leakage Sealing	Residential	15	GDS[90]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[91]
	Insulation – Opaque Shell	Residential	25	GDS[92]
	Plastic Window Insulation	Residential	1	See Note[93]
	Storm Window	Residential	20	DOE[94]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
	Window - Film	Residential	10	DEER 2014 EUL ID: GlazDaylt-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[95]
	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[96]

[89] Average/typical manufacturer warranty period for AC covers.
[90] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[91] Ibid.
[92] Ibid.
[93] 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
[94] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[95] 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
[96] 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[97]
	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[98]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER 2014[99] 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

[97] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.
[98] 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
[99] 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[100]
	Furnace, Gas Fired	Residential	22	DOE[101,102]
	Gas Heat Pump	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump - Air Source (ASHP) and Air-to-Water (AWHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[103]
	Heat Pump – PTHP	Residential	15	DEER 2014 EUL ID: HVAC-PTHP
	Refrigerant Charge Correction & Tune-Up – Air Conditioner and Heat Pump	Residential	10	DEER 2014 EUL ID: HV-RefChrg
	Tune-Up - Boiler	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Tune-Up - Furnace	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Unit Heater, Gas Fired	Residential	13	ASHRAE Handbook, 2015
HVAC - Control	Adaptive Photonic Control	Residential	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A

[100] 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

[101] 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

[102] 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

[103] 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[104]
	Thermostat – All Types	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[105]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[106]
Lighting[107]	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[108]
	Light Fixture	Residential LED (Interior)	50,000 hours	DLC[109]
			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

[104] NYSERDA Residential Electric Submetering Manual.
[105] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. pg. 16.
[106] Based on assumed EUL of integrated fan, which is expected to be the first component to fail.
[107] 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
[108] 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
[109] Placed on the Qualified Products List by the Design Light Consortium (DLC) 50,000 hours, according to the appropriate Application Category as specified in the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4 or higher.

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting[110]	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[111]
		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[112]
	Connected Lighting		Residential	3	GE and Philips Hue Bridge[113]

[110] 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

[111] 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

[112] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant. Available from: http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd_EPY9_Evaluation_Reports_Final/ComEd_PY9_LLLC_IPA_Program_Impact_Evaluation_Report_2018-06-05_Final.pdf

[113] 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[114]
	Solar Pool Heater	Residential	15	DOE[115]

[114] 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
[115] 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[116]
	Livestock Waterer	C&I	10	PA Consulting Group[117]
	Milk Pre-Cooler Heat Exchanger	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-ScrollComp
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[118]
	Variable Speed Drive Milk Pump Plate Cooler	C&I	15	PA Consulting Group[119]
	Variable Speed Drive Vacuum Pump	C&I	15	PA Consulting Group[120]
Appliance	Air Purifier	C&I	9	ENERGY STAR® Calc[121]
	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[122]
	Clothes Washer	C&I	11	DEER 2014 EUL ID: Appl-EffCW
	Cooking Equipment[123]	C&I	12	DEER 2014 EUL IDs: Various
	Dehumidifier	C&I	12	ENERGY STAR® Calc[124]
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ENERGY STAR®Calc[125]

[116] PG&E Work Paper PGE3PAGR117, October 12, 2017.
[117] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report dated August 25, 2009. Available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[118] Based on EUL's for Advanced Power Strips.
[119] 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
[120] 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
[121] 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
[122] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[123] Applicable to all kitchen cooking equipment not otherwise listed.
[124] ENERGY STAR® Dehumidifier Calculator. https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[125] ENERGY STAR® Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment. www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx?5da4-3d90&5da4-3d90

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Appliance	Fireplace	C&I	15	DOE[126]
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
	Induction Cooktop	C&I	16	DEER 2014 EUL ID: Appl-Elec_Cooking
	Refrigerator and Freezer	C&I	12	DEER 2014 EUL ID: Cook-SDRef
Appliance - Control	Advanced Power Strip (APS)	C&I	8	DEER 2014 EUL ID: Plug-OccSens
	Vending Machine and Novelty Cooler Control	C&I	5	DEER 2014 EUL ID: Plug-VendCtrler
Appliance Recycling	Air Conditioner – Room (RAC)	C&I	3	DEER 2014 EUL ID: HV-RAC-RUL
Building Shell	Air Leakage Sealing	C&I	15	GDS[127]
	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[128]
	Insulation - Opaque Shell	C&I	30	ET & CEC[129]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-WinFilm
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
	Air Curtains	C&I	15	DEER 2014 EUL ID: Motors-fan
Compressed Air	Air Compressor	C&I	13	Other State TRMs[130]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[131]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study[132]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [133]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [134]

[126] 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

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

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

[129] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.

[130] 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.

[131] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission.

[132] 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

[133] 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.

[134] Ibid.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Compressed Air	Flow Controller	C&I	13	Other State TRMs [135]
	Low Pressure Drop Filter	C&I	5	Navigant EUL Report [136]
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[137]
	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[138]
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[139]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER 2014[140] 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

[135] Ibid.
[136] Navigant ComEd Effective Useful Life Research Report. https://www.icc.illinois.gov/docket/P2017-0312/documents/287811/files/501915.pdf
[137] 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
[138] https://www.nrel.gov/docs/fy16osti/64541.pdf
[139] 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
[140] 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)	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: HVAC-ClTwrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[141]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	Economizer –Dual Enthalpy Air Side	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	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
	Energy and Heat Recovery Ventilator	C&I	14	PA Consulting Group[142]
	Furnace, Gas Fired	C&I	23	DOE[143,144]
	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[145]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group[146]
	Infrared Heater	C&I	17	GDS[147]

[141] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003).
[142] 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
[143] 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
[144] 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
[145] ASHRAE Owning and Operating Cost Database.
Available from: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
[146] 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
[147] 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

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	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[148]
	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[149]
	Kitchen Demand Ventilation Control	C&I	15	PG&E[150]
	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

[148] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013.
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[149] 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
[150] PG&E Work Paper WPSDGENRCC0019, June 15, 2012.

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
HVAC – Control	Thermostatic Radiator Valve		C&I	15	DOE[151]
	Advanced Rooftop Control		C&I	EUL = RUL of Existing RTU = RTU EUL – (Current Year – Year of Mfr.) **Default = 5**	N/A
Lighting[152]	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[153]
		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®[154]
		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®[155]
		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®[156]

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

[152] 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

[153] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4.

[154] 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).

[155] Ibid.

[156] Ibid.

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting[157]	Light Fixture	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
	LED Lamp		C&I	50,000 hours	DLC[158]
				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[159]
Lighting - Control	Bi-Level Lighting		C&I	15	ComEd[160]
	Integrated Interior Control		C&I	15	ComEd[161]
	Non-Integrated Interior Control		C&I	10	GDS[162]
	Plug-Load Occupancy Sensor		C&I	8	DEER[163]
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

[157] 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

[158] 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.

[159] 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

[160] 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

[161] Ibid.

[162] 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

[163] DEER value for lighting occupancy sensors.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Motors and Drives	Pool Pump	C&I	10	DEER 2014 EUL ID: OutD-PoolPump
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
	Elevator Modernization	C&I	15	DEER 2014[164]
Other	Building Operator Certification	C&I	13	ComEd[165]
	Heat Pump Pool Heater	C&I	15	DEER 2014 EUL ID: HV-Res HP
	High Efficiency Transformer	C&I	32	DOE[166]
	High Frequency Battery Charger	C&I	15	PG&E[167]
	High Viscosity Industrial Lubricant	C&I	10	ExxonMobil[168]
	Pool Heater	C&I	8	DOE[169]
	Solar Pool Cover	C&I	5	CALMAC[170]
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[171]
	Process Exhaust Filtration	C&I	15	CIBSE[172]
Refrigeration	Air-Cooled Refrigeration Condenser	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Automatic Door Closer for Walk-In Cooler/Freezer	C&I	8	DEER 2014 EUL ID: GrocWlkIn-DrClsr
	Cooler and Freezer Door Gasket	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	Cooler and Freezer Door Strip	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	EC Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr

[164] Assumes same EUL as VFD measure.
[165] Average measure life of capital measures from the ComEd CY2020 evaluation
[166] https://www.federalregister.gov/documents/2019/06/18/2019-12761/energy-conservation-program-energy-conservation-standards-for-distribution-transformers
[167] https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf, pg. 43.
[168] Information presented in the ExxonMobil study is confidential.
[169] 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
[170] http://www.calmac.org/publications/PoolCoverReport_2015_Final_Report_Appendices.pdf
[171] PG&E Work Paper PGECOAPP123, August 22, 2017.
[172] 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	Equipment (Condenser, Compressor, and Sub-cooling)	C&I	15	DEER 2014 EUL ID: GrocSys-MechSubcl
	Evaporator Fan Motor – with Permanent Magnet Synchronous Motor (PMSM)	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	Refrigerated Case Door	C&I	12	DEER 2014 EUL ID: GrocDisp-FixtDoors
	Refrigerated Case Night Cover	C&I	5	DEER 2014 EUL ID: GrocDisp-DispCvrs
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Condenser Pressure and Temperature Control	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Floating Head Pressure Control	C&I	10	PA Consulting Group [173]

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.
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Record of Revision

Record of Revision Number	Issue Date
EUL's originally listed in July 18, 2011 Order	7/18/2011
Additional EUL's posted on web site	Subsequent to 7/18/2011 Order
7-13-28	7/31/2013
6-14-1	6/19/2014
6-14-2	6/19/2014
6-15-4	6/1/2015
6-16-2	6/30/2016
1-17-8	12/31/2016
6-17-16	6/30/2017
9-17-11	9/30/2017
12-17-17	12/31/2017
3-18-21	3/31/2018
6-18-23	6/30/2018
9-18-21	9/30/2018
12-18-17	12/28/2018
3-19-16	3/29/2019
6-19-14	6/30/2019
9-19-10	9/30/2019
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