Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
3-21-05	R	4/14/2021	4/14/2021	R/MF Insulation – Opaque Shell	Corrected heating component of Annual Electric Energy Savings equation; Removed restriction of central equipment only on existing cooling consideration;	Pg. 74
3-21-09	A	4/14/2021	4/14/2021	C/I Clothes Washer	New Measure Added	Pg. xx
3-21-11	A	4/14/2021	4/14/2021	C/I Air Leakage Sealing	New Measure Added	Pg. xx
3-21-12	A	4/14/2021	4/14/2021	C/I Insulation – Opaque Shell	New Measure Added	Pg. xx
3-21-13	R	4/14/2021	4/14/2021	C/I Instantaneous Water Heater	Clarified Baseline Efficiencies default as application for new construction only; updated new construction Baseline Efficiencies default to100-gallon storage type water heater	Pg. 438
3-21-14	A	4/14/2021	4/14/2021	C/I Drain Water Heat Recovery (DWHR)	New Measure Added	Pg. xx
3-21-15	A	4/14/2021	4/14/2021	C/I PEI-Rated Clean Water Pump	New Measure Added	Pg. xx
3-21-16	A	4/14/2021	4/14/2021	C/I High Efficiency Transformer	New Measure Added	Pg. xx
3-21-17	A	4/14/2021	4/14/2021	C/I High Frequency Battery Charger	New Measure Added	Pg. xx
3-21-18	R	4/14/2021	4/14/2021	Appendix P	Updated EUL entries for all measures contained in this Record of Revision	Pg. 996

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between January 1, 2021 – April 14, 2021.

BUILDING SHELL

INSULATION - OPAQUE SHELL

Measure Description

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

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

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

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

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

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
$\Delta kWh_{cooling}$	= Annual electric cooling energy savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
$R_{baseline}$		From application. If unknown, lookup in Baseline Efficiency section below, based on building vintage and building envelope component.
ΔR		From application.
A		From application.
$F_{framing}$	Walls: 0.25 Ceilings: 0.07	ASHRAE.[1]
$F_{ElecCool}$		If an electric cooling system is present, set equal to 1. Otherwise, set equal to 0.

[1] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.

Variable	Value	Notes
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 or use 13 SEER, assuming a minimally code compliant, 3-ton, split system AC.[2]
HSPF		From application or 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.
EER		From application. If unknown, baseline EER is established as follows[4]: $EER = (1.12 \times SEER) - (0.02 \times SEER^2)$
$Eff_{FuelHeat}$		From application. If unknown, lookup based on system size and type in Baseline Efficiencies from which Energy Savings are Calculated section below.
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[5]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a building envelope with insufficient insulation (i.e., not compliant with all applicable construction code requirements). R-value of existing insulation shall come from application. If unknown, lookup in the Existing Building Envelope R-value table below based on building vintage and building envelope component. Alternatively, R-3.1 per inch of existing insulation may be applied.[6]

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[2] ECCCNYS 2020, Table C403.3.2(1))
[3] Ibid.
[4] DOE, Building America House Simulation Protocols, October 2010
[5] 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.
[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).

Existing Building Envelope R-value

Vintage	Wall	Ceiling
Pre-war uninsulated brick[7]	4	2
Prior to 1979[8]	7	11
From 1979 through 2006[9]	11	19
From 2007 through the present[10]	19	38 (Climate Zones 4 & 5) 49 (Climate Zone 6)

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

Fossil Fuel Fired Heating System Baseline Efficiencies: Systems Serving Single Units[11]

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6
Warm Air Furnace, Gas Fired	All Capacities	0.80 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[12] 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 or 0.80 E_t
	≥ 225 kBTU/h	0.80 Et
Warm Air Furnace, Oil Fired	< 225 kBTU/h	0.83 AFUE or 0.80 E_t
	≥ 225 kBTU/h	0.80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec

[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

[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] 10 CFR 430.32(e)

[12] 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, Oil Fired	All Capacities	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et
	> 2,500 kBTU/h	0.82 Ec
Boiler, Hot Water, Oil Fired	< 300 kBTU/h	0.84 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et
	> 2,500 kBTU/h	0.84 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et
	> 2,500 kBTU/h	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et
	> 2,500 kBTU/h	0.77 Et
Boiler, Steam, Oil Fired	< 300 kBTU/h	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.81 Et
	> 2,500 kBTU/h	0.81 Et

Compliance Efficiency from which Incentives are Calculated

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

Opaque shell insulation improvements performed under this measure shall be installed such that that all altered envelope components comply with all federal, state, local and municipal codes and standards applicable to alterations to existing buildings, including but not limited to Section R503.1 of ECCCNYS 2020[13] 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.

Heating and Cooling Degree Days[14]

City	HDD	CDD
Albany	6,680	597
Binghamton	7,193	382

[13] ECCCNYS 2020, Section R503 Building Thermal Envelope

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

City	HDD	CDD
Buffalo	6,617	544
Massena	8,196	363
NYC	4,671	1,160
Poughkeepsie	6,210	671
Syracuse	6,651	570

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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3. ECCCNYS 2020 Section R403 Systems
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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
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7. ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.
8. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

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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	4/14/2021

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Appliance

Clothes Washer

Measure Description

This measure is applicable to commercial grade clothes washers meeting the criteria established under the ENERGY STAR® Program, Version 8.0, effective February 5, 2018, installed in commercial settings.[15] ENERGY STAR® clothes washers have a higher Modified Energy Factor (MEF) and a lower Integrated Water Factor (IWF), saving energy and water with greater tub capacities and sophisticated wash and rinse systems. Rather than filling the tub with water, efficient wash cycles are achieved by spinning or flipping clothes through a stream of water. Efficient rinse cycles are achieved through high-pressure spraying instead of soaking clothes. Reduced dryer load represents additional energy savings associated with the thorough removal of water from the clothes in the washer. Clothes washers originally qualified for the ENERGY STAR® label in 1997. Clothes washers that have earned this label use approximately 25% less energy and 33% less water than comparable non-qualified models.[16]

This measure addresses installation of soft-mounted[17] front-loading clothes washers.[18] This measure applies to commercial equipment installed in multifamily common areas, coin laundries, hospitals, hotels and motels.

The algorithms, inputs, and savings presented below assume a normal replacement scenario.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times Cycles_{daily} \times days \times capacity \times \left(\frac{1}{MEF_{baseline}} - \frac{1}{MEF_{ee}}\right) \times \left[F_{washer} + (F_{wh} \times ElecSF_{wh}) + (F_{dryer} \times ElecSF_{dryer})\right]$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{days \times 24} \times CF$$

[15] ENERGY STAR® Program Requirements Product Specification for Clothes Washers, Eligibility Criteria Version 8.0, February 2018
[16] Efficiency of ENERGY STAR® products: https://www.energystar.gov/products/appliances/clothes_washers
[17] Soft-mounted washing machines are built in a cradle that contains springs and shock absorbers to isolate the drum from the frame of the washer.
[18] Per 10 CFR 431.110 (a)

Annual Fuel Energy Savings

$$\Delta MMBtu = units \times Cycles_{daily} \times days \times capacity \times \left(\frac{1}{MEF_{baseline}} - \frac{1}{MEF_{ee}}\right) \times \left[\frac{(F_{wh}}{E_{t,fuel}} \times FuelSF_{wh}) + (F_{dryer} \times FuelSF_{dryer} \times 1.12)\right] \times \frac{3{,}412}{1{,}000{,}000}$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
$Cycles_{daily}$	= Number of dryer cycles per day
$ElecSF_{wh}$	= Electric Savings Factor for water heaters
$ElecSF_{dryer}$	= Electric Savings Factor for dryers
$FuelSF_{wh}$	= Fuel Savings Factor for water heaters
$FuelSF_{dryer}$	= Fuel Savings Factor for dryers
$MEF_{baseline}$	= Baseline Modified Energy Factor
MEF_{ee}	= Energy Efficient Modified Energy Factor
F_{washer}	= Percentage of savings attributable to washer
F_{wh}	= Percentage of savings attributable to water heater
F_{dryer}	= Percentage of savings attributable to dryer
capacity	= Clothes Washer rated capacity (cu.ft.)
days	= Number of operating days per year
$E_{t,fuel}$	= Water heater thermal efficiency
CF	= Coincidence Factor
1.12	= Gas dryer correction factor[19]
24	= Hours in one day
3,412	= Conversion factor, one kWh equals 3,412 BTU
1,000,000	= Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$MEF_{baseline}$		Lookup based on Equipment class in the table in Baseline Efficiency section below.
MEF_{ee}		From application.
F_{washer}	0.08	Calculated from conventions drawn from ENERGY STAR and 10 CFR[20]
F_{wh}	0.33	Calculated from conventions drawn from ENERGY STAR and 10 CFR[21]

[19] A gas dryer correction factor corrects for the differential in typical efficiency between electric and gas dryers. U.S. Department of Energy (DOE). 2012. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers
[20] Calculated based on defaults from ENERGY STAR and 10 CFR 431.156
[21] Calculated based on defaults from ENERGY STAR and 10 CFR 431.156

Variable	Value	Notes
F_{dryer}	0.59	Calculated from conventions drawn from ENERGY STAR and 10 CFR[22]
$ElecSF_{wh}$	Electric WH: 1.0 Fuel WH: 0 Unknown: 0.43	Based on EIA Commercial Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[23]
$ElecSF_{dryer}$	Electric Dryer: 1.0 Gas Dryer: 0 Unknown: 0.43	Based on EIA Commercial Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[24]
$FuelSF_{wh}$	Electric WH: 0 Fuel WH: 1.0 Unknown: 0.57	Based on EIA Commercial Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[25]
$FuelSF_{dryer}$	Electric Dryer: 0 Gas Dryer: 1.0 Unknown: 0.57	Based on EIA Commercial Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[26]
$E_{t,fuel}$	0.80	Thermal efficiency of fuel water heater.[27]
$Cycles_{daily}$	Laundromat: 4.3 Multi-family: 3.4 Hospital/Hotel/Motel: 10.4	State of the Self-Service Industry Laundry Report.[28] ACEEE White Paper.[29] Laundry Planning Guide, EDRO.[30]
Capacity		From application.
days		From application.
CF	1.0	

Integrated Water Factor, IWF[31] (gal/ft^3/cycle) is the quotient of the total weighted per-cycle water consumption for all wash cycles in gallons divided by the cubic foot (or liter) capacity of the clothes washer. A lower value reflects a more efficient clothes washer[32]. Manufacturers must submit their water consumption factors with their ENERGY STAR® certified commercial clothes washers.

[22] Calculated based on defaults from ENERGY STAR and 10 CFR 431.156
[23] EIA Commercial Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States, Table B4. Census region and division, number of buildings ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with electric, fuel oil or gas water heating.)
[24] Ibid, water heater values are applied as proxy.
[25] EIA Commercial Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States, Table B4. Census region and division, number of buildings ("Unknown" calculated as the number of homes with gas or fuel water heating divided by the total number of homes with electric, fuel oil or gas water heating.)
[26] Ibid, water heater values are applied as proxy.
[27] Per 10 CFR 431.110 (a)
[28] '2014-2015 State of the Self-Service Laundry Industry Report' Carlo Calma April 2015.
[29] Saving Energy and Water through State Programs for Clothes Washer Replacement in the Great Lakes region
[30] Laundry Planning Guide, EDRO, January 2015.
[31] 10 CFR 430 Subpart B, Appendix J2
[32] ENERGY STAR® Program Requirements Product Specification for Clothes Washers, Eligibility Criteria Version 8.0, February 2018

Modified energy factor (ft^3/kWh/cycle), is the quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0.[33]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline equipment class should be determined based on existing conditions and the baseline MEF should be based on that equipment class. If unknown or for new construction/installation, a front-loading baseline should be assumed, as specified in the Code of Federal Regulations.[34]

Equipment Class	Modified Energy Factor (MEFJ2)	Integrated Water Factor (IWF)
Front-Loading	2.00	4.1

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified clothes washer. The equipment must be a soft-mounted front-loading commercial clothes washer with a MEF of 2.20 and IWF ≤ 4.0 with a volume lesser than or equal to 8.0 cubic feet.

Operating Hours

Equipment operating days per year shall be taken from application. This assumption is applied to produce conservative demand savings estimates.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

High efficiency clothes washers more effectively remove moisture from clothing during spin cycles. This reduces the amount of time necessary for drying cycles and leads to energy savings. Clothes dryer energy savings are considered in overall energy savings calculations above.

Ancillary Electric Savings Impacts

High efficiency clothes washers more effectively remove moisture from clothing during spin cycles. This reduces the amount of time necessary for drying cycles and leads to energy savings. Clothes dryer energy savings are considered in overall energy savings calculations above.

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[33] A conservative approach that suggests savings are equally likely to occur at any time throughout the year.
[34] 10 CFR 431.156

References

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2. ENERGY STAR® Certified Products, Appliances, Clothes Washers
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3. Purchase energy-saving products, 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
4. 10 CFR 430 Subpart B, Appendix J2 - Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-automatic Clothes Washers
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Record of Revision

Record of Revision Number	Issue Date
3-21-9	4/14/2021

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BUILDING SHELL

AIR LEAKAGE SEALING

Measure Description

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

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

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

In cases where blower door testing is conducted before and after implementation of air sealing treatments, those measurements shall be utilized in the estimation of energy impacts via the method below. A blower door test is performed to measure the leakage rate by depressurizing the building to a standard pressure difference of 75 Pascals or 0.3 inches of water. The flowrate indicates the leakage rate, or infiltration and exfiltration rate, of the building shell.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

$$\Delta kWh_{cooling} = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,cooling} \times F_h}\right] \times SF \times LM \times 1.08 \times CDD \times 24}{Eff_{ElecCool} \times 1{,}000}$$

$$\Delta kWh_{heating} = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,heating} \times F_h}\right] \times SF \times 1.08 \times HDD \times 24 \times F_{ElecHeat}}{HSPF \times 1{,}000}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,cooling} \times F_h}\right] \times SF \times LM \times 1.08}{EER \times 1{,}000} \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,heating} \times F_h}\right] \times SF \times 1.08 \times HDD \times 24 \times F_{FuelHeat}}{Eff_{FuelHeat} \times 1{,}000{,}000}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
$\Delta kWh_{cooling}$	= Annual electric cooling energy savings
$\Delta kWh_{heating}$	= Annual electric heating energy savings
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
(CFM_{75}/SF)	= Infiltration rate (cubic foot per minute per building square foot) at a negative pressure differential of 75 Pa or 0.3 inches of water[35]
$F_{n,cooling}$	= Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, climate zone factor during cooling season
$F_{n,heating}$	= Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, climate zone factor during heating season
F_h	= Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, building height factor
LM	= Latent Multiplier, used to convert the sensible cooling savings calculated to a value representing sensible and latent cooling loads
SF	= Square footage of the above- and below-grade building envelope[36] (ft^2)
CDD	= Cooling Degree Day
HDD	= Heating Degree Day
$Eff_{ElecCool}$	= Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (>65,000 BTU/h)
HSPF	= Seasonal average energy efficiency of electric heating equipment. Heating Seasonal Performance Factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heating) during the heating season / total electric energy heat pump consumed (in watt-hour); if equipment efficiency is reported in COP, convert to HSPF using the equivalency HSPF = COP x 3.412
EER	= Energy efficiency ratio under peak conditions (BTU/watt-hour)
$Eff_{FuelHeat}$	= Efficiency of fuel heating equipment (AFUE, E_t, or E_c)

[35] ECCCNYS 2020 C402.5 Air leakage – thermal envelope (Mandatory)
[36] ECCCNYS 2020 C406.9 Reduced air infiltration

$F_{ElecHeat}$ = Electric heating factor; used to account for the presence or absence of an electric heating system
$F_{FuelHeat}$ = Fuel heating factor; used to account for the presence or absence of a fossil fuel heating system
CF = Coincidence factor
1.08 = Specific heat of air x density of inlet air @ 70ºF x 60 min/hr, in BTU/h-ºF-CFM[37]
24 = Hours in a 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
$(CFM_{75}/SF)_{baseline}$		From application, results from blower door test. If pre-implementation blower door test results are unavailable, use 0.40 CFM_{75}/SF as default.[38]
$(CFM_{75}/SF)_{ee}$		From application, results from blower door test. If post -implementation blower door test results are unavailable, use 0.25 CFM_{75}/SF as default.[39,40,41]
SF		From application.
$F_{n,cooling}$		Look up in Infiltration-Leakage Ratio, Climate Zone table below based on location and building shielding class, as defined below.
$F_{n,heating}$		Look up in Infiltration-Leakage Ratio, Climate Zone table below based on location and building shielding class, as defined below.
F_h	$= {N_{stories}}^{-0.3}$	Based on the number of conditioned stories in the building, from application.[42] The selected value should reflect the number of stories located inside the conditioned envelope of the building. Unconditioned basements and attics should not be included. Upper levels without full height perimeter walls shall be considered as half-stories (0.5).

[37] 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.
[38] ECCCNYS 2020 C402.5 Air leakage – thermal envelope (Mandatory)
[39] ECCCNYS 2020 C406.9 Reduced air infiltration
[40] U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, Version 3, May 11, 2012, p. 7
[41] NIST, Analysis of U.S. Commercial Building Envelope Air Leakage Database to Support Sustainable Building Design. Analysis of air sealing in commercial buildings demonstrates buildings exceeding ECCCNYS Additional Efficiency Packages requirements.
[42] LBL, Exegesis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings, M. Sherman, July 1986, p. 12

Variable	Value	Notes
LM		Look up in the Latent Multiplier table below, based on location.
CDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table in the Operating Hours section below.
HDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table in the Operating Hours section below.
$Eff_{ElecCool}$		From application. SEER or IEER shall be used, based on nameplate rating metric of existing equipment.
HSPF		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
EER		From application. If unknown, baseline EER is established as follows[43]: $EER = (1.12 \times \mathrm{Eff}_{\mathrm{ElecCool}}) - \left(0.02 \times \mathrm{Eff}_{\mathrm{ElecCool}}{}^{2}\right)$
$Eff_{heating}$		From application. E_c, E_t, or AFUE shall be used, based on nameplate rating metric of existing equipment.
$F_{ElecHeat}$		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.
CF	NYC: 0.822 Outside of NYC: 0.477	

Infiltration-Leakage Ratio, Climate Zone

The Infiltration-Leakage Ratio, Climate Zone converts pressurized blower door testing results to natural infiltration rates with consideration for climate zone. Look up $F_{n,cooling}$ and $F_{n,heating}$ in the tables below based on climate zone and shielding class, as defined below, based on application.[44]

[43] DOE, Building America House Simulation Protocols, October 2010

[44] Infiltration-Leakage Ratio is calculated based on the derivation for air flow rate as outlined in ASHRAE Handbook – Fundamentals, 2017, Chapter 16 Ventilation and Infiltration, Section 10 Simplified Models of Residential Ventilation and Infiltration, p. 16.24: Airflow Rate (CFM) = Effective Air Leakage Area Conversion Factor * SQRT(Stack Coefficient * | Temperature Difference | + Wind Coefficient * (Wind Velocity)^2). Stack Coefficient and Wind Coefficient values are applied from Table 4 Basic Model Stack Coefficient C_s and Table 6 Basic Model Wind Coefficient C_w. Hourly wind speeds and ambient air temperatures are downloaded from NCEI. Effective Air Leakage Area Conversion Factor is calculated as outlined in Computing Manual J Infiltration Loads Based Upon a Target Envelope Leakage Requirement (ACCA, October 2016) Sections 2 and 5. At a pressurization of 75 CFM and assuming sea level, Equivalent Leakage Ratio = (0.2835*(4)^0.65)/(75)^0.65 = 0.042. Applying a building balance point of 65, hourly Normalized Airflow Rates are calculated for the heating season (below 65F) and the cooling season (above 65F). The inverse of the average of the hourly airflow rates are applied as the seasonal factors, $F_{n,cooling}$ and $F_{n,heating}$, as outlined in Infiltration Factor Calculation Methodology, Bruce Harley,

Shielding Class[45]:

(1) No shielding on any side
(2) A few nearby obstructions
(3) A collection of obstructions within 25 feet
(4) Substantial number of obstructions shield most of the perimeter – typical suburban setting
(5) Building surrounded by large structures – typical urban setting

Shielding Class	$F_{n,cooling}$						
	Albany	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
1	12	11	10	11	9	11	12
2	14	13	11	12	10	13	14
3	16	15	13	15	12	15	16
4	20	19	17	19	16	19	20
5	34	32	29	32	27	33	34

Shielding Class	$F_{n,heating}$						
	Albany	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
1	12	10	9	10	8	10	11
2	13	11	10	11	9	11	12
3	15	13	12	13	10	13	15
4	19	17	15	17	13	17	18
5	28	26	24	26	22	26	27

Latent Multiplier[46]

The Latent Multiplier converts the sensible cooling load savings captured in the savings equation to a savings capturing both latent and sensible load savings. The multiplier accommodates for the energy savings impacts associated with decreased humidity influx in a building with improved air sealing. During the cooling season, humidity poses an additional load on the cooling system. The Latent Multiplier is the ratio of total heat load (latent and sensible) to sensible heat load. Set indoor conditions are taken as 75ºF and 50% rh.

Location	Latent Load	Sensible Load	Latent Multiplier (LM)
Albany	2.3	0.4	6.8
Binghamton	2.2	0.1	23.0
Buffalo	1.9	0.2	10.5
Massena	2.1	0.2	11.5
NYC	2.6	0.5	6.2
Poughkeepsie*	3.0	0.6	6.0
Syracuse	2.1	0.3	8.0

*Poughkeepsie data is approximated from Hartford, Connecticut due to limited available data

Senior Manager, Applied Building Science, CLEAResult, 11/18/2015, as published in a IL TRM Memo, November 25, 2015.

[45] ASHRAE Handbook – Fundamentals, 2017. Chapter 16 Ventilation and Infiltration, Section 10 Simplified Models of Residential Ventilation and Infiltration, Table 5 Local Shelter Classes

[46] ASHRAE Journal, Dehumidification and Cooling Loads From Ventilation Air, Lewis Harriman, November 1997

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.822 for NYC and 0.477 outside of NYC.[47]

Baseline Efficiencies from which Energy Savings are Calculated

Baseline flow rate CFM_{75}/SF shall come from blower door testing. If pre-implementation blower-door results are unavailable, use default of 0.4 CFM_{75}/SF.[48]

Compliance Efficiency from which Incentives are Calculated

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

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

Operating Hours

Effective heating and cooling hours associated with benefits of air sealing are established via the Heating and Cooling Degree Days table below.

Heating and Cooling Degree Days[49]

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

Effective Useful Life (EUL)

See Appendix P.

[47] C&I Unitary HVAC Load Shape Project Final Report, KEMA, 2011, Table 0-5: NY - Inland and NY - Urban/Coastal

[48] ECCCNYS 2020 C402.5 Air leakage – thermal envelope (Mandatory)

[49] HDD/CDD taken from NCEI 1981-2010 climate normal climate normal using a 65ºF 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.

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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BUILDING SHELL

INSULATION - OPAQUE SHELL

Measure Description

This measure covers the installation of wall and ceiling insulation to reduce the thermal conductance of the building envelope. Energy and demand savings are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured in order to estimate energy savings. This measure is only applicable as a retrofit in existing buildings. This measure is not applicable to gut rehab/major renovation projects which entail whole-building envelope alterations that trigger more stringent code provisions, limiting potential incremental savings.

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

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

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

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

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

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

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

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fuel energy savings
$\Delta kWh_{cooling}$ = Annual electric cooling energy savings
$\Delta kWh_{heating}$ = Annual electric heating energy savings

$R_{baseline}$ = R-value of existing insulation (ft²-F°-h/BTU)
ΔR = Difference in R-value between installed insulation and existing insulation (ft²-F°-h/BTU)
A = Area of insulated surfaces (SF)
$F_{framing}$ = Framing factor
F_{CEC} = Central electric cooling factor; used to account for the presence or absence of a central electric cooling system
CDD = Cooling Degree Days - The number of degrees that a day's average temperature is above some baseline temperature, which represents the temperature above which buildings need to be cooled. The baseline temperature is typically 65°F, but may vary based on application.
HDD = Heating Degree Days - The number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The baseline temperature is typically 65°F, but may vary based on application.
$F_{ElecHeat}$ = Electric heating factor, used to account for the presence or absence of an electric heating system
$F_{FuelHeat}$ = Fuel heating factor, used to account for the presence or absence of a fuel heating system
$Eff_{ElecCool}$ = Seasonal average energy efficiency of electric cooling equipment, BTU/watt-hour, using either SEER (<65,000 BTU/h) or IEER (≥65,000 BTU/h)
HSPF = Seasonal average energy efficiency of electric heating equipment. Heating Seasonal Performance Factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heating) during the heating season / total electric energy heat pump consumed (in watt-hour); if equipment efficiency is reported in COP, convert to HSPF using the equivalency HSPF = COP x 3.412
EER = Energy efficiency ratio under peak conditions (BTU/watt-hour)
$Eff_{FuelHeat}$ = Efficiency of fuel heating equipment (AFUE, Et, or Ec)
CF = Coincidence factor
24 = Hours in one day
1,000 = Conversion factor, one kW equals 1,000 watts
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$R_{baseline}$		From application. If unknown, lookup in Baseline Efficiency section below, based on building vintage and building envelope component.
ΔR		From application.
A		From application.

Variable	Value	Notes
$F_{framing}$	Walls: 0.25 Ceilings: 0.07	Thermal Design and Code Compliance[50] California Energy Commission, 2013 Building Energy Efficiency Standards[51]
F_{CEC}		If a central electric cooling system is present, set equal to 1. Otherwise, set equal to 0.
CDD		From application. If unknown, lookup based on location in Heating and Cooling Degree Days table below.
HDD		From application. If unknown, 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.
$Eff_{ElecCool}$		From application. SEER or IEER shall be used, based on nameplate rating metric of existing equipment.
HSPF		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.
EER		From application.
$Eff_{FuelHeat}$		From application. E_c, E_t, or AFUE shall be used, based on nameplate rating metric of existing equipment.
CF	NYC: 0.822 Outside of NYC: 0.477	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.822 for NYC and 0.477 outside of NYC.[52]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a building envelope with insufficient insulation (i.e., not compliant with all applicable construction code requirements). R-value of existing insulation shall come from application. If unknown, lookup wall and ceiling R-values based on vintage and building type from Appendix A.

[50] Thermal Design and Code Compliance for Cold-Formed Steel Walls, 2015, American Iron and Steel Institute, pg 17
[51] California Energy Commission, 2013 Building Energy Efficiency Standards, Appendix JA4(2). 7.25 percent of the attic insulation above the framing members is assumed to be at half depth, due to decreased depth of insulation at the eaves. This assumption was derived using the parallel path method as documented in the 2009 ASHRAE Handbook of Fundamentals.
[52] C&I Unitary HVAC Load Shape Project Final Report, KEMA, 2011, Table 0-5: NY - Inland and NY - Urban/Coastal

Compliance Efficiency from which Incentives are Calculated

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

Opaque shell insulation improvements performed under this measure shall be installed such that that all altered envelope components comply with all federal, state, local and municipal codes and standards applicable to alterations to existing buildings, including but not limited to Section C503.1 of ECCCNYS 2020[53] 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.

Heating and Cooling Degree Days[54]

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

[53] ECCCNYS 2020, Section C503 Building Thermal Envelope

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

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DOMESTIC HOT WATER

INSTANTANEOUS WATER HEATER

Measure Description

This measure covers the installation of high-efficiency fuel and electric instantaneous water heaters, which heat water but contain no more than one gallon of water per 4,000 BTU/h of input. It is applicable to fuel-fired instantaneous water heaters with a rated input greater than 200,000 BTU/h and electric instantaneous water heaters with a rated input greater than 12 kW.[55] This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating.

This measure applies to replacement of existing storage type water heaters using the same heating fuel (fuel or electric) as the efficient case. For new construction, this measure assumes baseline to be a standard efficiency water heater using the same heating fuel (fuel or electric) as the efficient case.

This measure applies to commercial grade water heaters only. For residential-duty water heaters installed in commercial settings, the Residential Storage Tank and Instantaneous Domestic Water Heater methodology detailed in this document shall be employed utilizing typical GPD values as defined in the “Gallons per Day (GPD)” section below.

Method for Calculating Annual Energy and Peak Coincidence Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}}\right) + \frac{UA_{baseline} \times \Delta T_{amb} \times 8{,}760}{E_{t,baseline} \times 3{,}412}\right]$$

Summer Peak Coincident Demand Savings

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

Annual Fuel Energy Savings

$$\Delta MMBtu = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{1{,}000{,}000} \times \left(\frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}}\right) + \frac{UA_{baseline} \times \Delta T_{amb} \times 8{,}760}{E_{t,baseline} \times 1{,}000{,}000}\right]$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fuel energy savings
units = Number of measures installed under the program
GPD = Gallons per day

[55] 10 CFR 431.102

ΔT_{main} = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb} = Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
E_t = Thermal efficiency
UA = Overall heat loss coefficient (BTU/h-°F)
CF = Coincidence factor
365 = Days in one year
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kWh equals 3,412 BTU
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU
8,760 = Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
GPD		From application, or lookup based on building type in GPD table below.
ΔT_{main}	$T_{set} - T_{main}$	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	$T_{set} - T_{amb}$	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
T_{set}		Water heater set point temperature (°F). From application, or use 140°F.[56]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
T_{amb}	70	Surrounding ambient air temperature (°F). 57
$E_{t,baseline}$	Electric: 0.98 Fuel: 0.80	Thermal efficiency of the baseline condition[58,] 59
$E_{t,ee}$		Thermal efficiency for energy efficient measure, from application
$UA_{baseline}$		Overall heat loss coefficient of the baseline condition, calculate based on baseline standby loss per the Overall Heat Loss Coefficient section below.
CF	0.8	

[56] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
[57] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.
[58] Fuel: 10 CFR 431.110 (a)
[59] Electric: Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

Gallons per Day (GPD)

The average daily hot water usage, expressed in gallons per day, for several commercial facility types is tabulated below. Daily hot water usage can be calculated based on the GPD and site-specific metric in the Rate column, or default values can be referenced directly from the GPD column.

Building Type	GPD	Rate	Notes/Assumptions	Source
Assembly	239	7.02 GPD per 1,000 ft^2	Assumes 10% hot water, 34,000 ft^2	EIA [60]: Public Assembly
Auto Repair	25	4.89 GPD per 1,000 ft^2	Assumes 10% hot water, 5,150 ft^2	EIA: Other
Big Box Retail	448	3.43 GPD per 1,000 ft^2	Assumes 10% hot water, 130,500 ft^2	EIA: Mercantile
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL [61]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation [62]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC [63]: Quick Service
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service
Grocery	172	3.43 GPD per 1,000 ft^2	Assumes 10% hot water, 50,000 ft^2	EIA: Mercantile
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers
Hospital	16,938	54.42 GPD per 1,000 ft^2	Assumes 40% hot water, 250,000 ft^2	EIA: Health Care, Inpatient
Hotel	9,104	45.52 GPD per 1,000 ft^2	Assumes 40% hot water, 200,000 ft^2	EIA: Lodging
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office
Large Retail	446	3.43 GPD per 1,000 ft^2	Assumes 10% hot water, 130,000 ft^2	EIA: Mercantile
Light Industrial	489	4.89 GPD per 1,000 ft^2	Assumes 10% hot water, 100,000 ft^2	EIA: Other
Motel	1,366	45.52 GPD per 1,000 ft^2	Assumes 40% hot water, 30,000 ft^2	EIA: Lodging
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation
Refrigerated Warehouse	86	0.93 GPD per 1,000 ft^2	Assumes 10% hot water, 92,000 ft^2	EIA: Warehouse and Storage
Religious	77	7.02 GPD per 1,000 ft^2	Assumes 10% hot water, 11,000 ft^2	EIA: Public Assembly
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office
Small Retail	27	3.43 GPD per 1,000 ft^2	Assumes 10% hot water, 8,000 ft^2	EIA: Mercantile
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School
Warehouse	465	0.93 GPD per 1,000 ft^2	Assumes 10% hot water, 500,000 ft^2	EIA: Warehouse and Storage
Other	Calculate	4.89 GPD per 1,000 ft^2	Assumes 10% hot water	EIA: Other

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[64] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[65] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3

[60] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012
[61] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011
[62] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016
[63] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010
[64] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[65] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

City	Annual average outdoor temperature[65] (°F)	T_{main} (°F)
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Overall Heat Loss Coefficient ($UA_{baseline}$)

Tank overall heat loss coefficient is calculated from the equipment standby loss specification. To calculate $UA_{baseline}$, use the appropriate intermediate standby loss equation from the Baseline Standby Losses section below.

$$UA = \frac{SL}{70}$$

where:

SL = Standby heat loss (BTU/h). For the baseline condition ($SL_{baseline}$), use the appropriate intermediate standby loss equation from the Baseline Standby Losses section below.

70 = Temperature difference associated with standby loss specification (°F)[66]

Baseline Standby Losses ($SL_{baseline}$)

Standby losses ($SL_{baseline}$) for large electric storage type water heaters (> 12kW and > 20 gallons):[67]

$$SL_{baseline} = 20 + 35\sqrt{v_{baseline}}$$

where:

$v_{baseline}$ = Baseline tank volume (gal). If unknown, assume 150 gallons.

Standby losses ($SL_{baseline}$) for large oil and gas storage type water heaters (> 75,000 BTU/h input capacity (Q) and storage size > 1 gallon per 4000 BTU/h):[68]

$$SL_{baseline} = \frac{Q_{baseline}}{800} + 110\sqrt{v_{baseline}}$$

where:

$v_{baseline}$ = Baseline tank volume (gal). If unknown, assume 150 gallons.

$Q_{baseline}$ = Baseline input capacity (BTU/h). If unknown, assume 200,000 BTU/h.

[66] 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters

[67] Ibid.

[68] Ibid.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8[69]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a standard efficiency fuel or electric storage type water heater (fuel type equivalent to the efficient case) with tank volume and input capacity equivalent to those of the existing equipment, UA value calculated as prescribed above and a thermal efficiency of 0.80 (fuel) or 0.98 (electric). For new construction, assume the baseline condition consists of a 100-gallon storage type water heater with an input capacity of 200,000 BTU/h.[70]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a fuel or electric instantaneous water heater as defined in the Measure Description section above. fuel tankless water heaters must meet the minimum qualifying efficiency for ENERGY STAR® certification of a thermal efficiency greater than or equal to 0.94.[71] Electric tankless water heaters must meet or exceed the efficiency of the baseline condition with a thermal efficiency greater than or equal to 0.98.

Effective Useful Life (EUL)

See Appendix P.

Operating Hours

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

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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[69] *No source specified – update pending availability and review of applicable references.*
[70] Based on the average storage size and capacity of AHRI-certified commercial storage type water heaters per the ARHI Directory (https://www.ahridirectory.org/Search/SearchHome)
[71] ENERGY STAR® Commercial Water Heater Key Product Criteria

References

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Available from:
https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf
12. ENERGY STAR® Commercial Water Heater Key Product Criteria
Available from:
https://www.energystar.gov/products/water_heaters/commercial_water_heaters/key_product_criteria

Record of Revision

Record of Revision Number	**Issue Date**
6-18-20	6/26/2018
3-21-13	4/14/2021

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DOMESTIC HOT WATER – CONTROL

DRAIN WATER HEAT RECOVERY (DWHR)

Measure Description

This measure covers the installation of drain water heat recovery systems on a main waste drain in commercial applications. Drain water heat recovery (DWHR) systems are drainage heat exchangers that recover heat from drain greywater to preheat cold water entering the water heater. By preheating cold water entering the storage tank, the water heater consumes less energy to heat the water to the desired temperature.

This measure is only applicable to buildings with storage type water heaters.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Water Heating Only)

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \frac{1}{E_{t,elec}} \times ESF$$

Summer Peak Coincident Demand Savings (Electric Water Heating Only)

$$\Delta kW = units \times \frac{UA \times \Delta T_{amb}}{3{,}412} \times \frac{1}{E_{t,elec}} \times ESF \times CF$$

Annual Fuel Energy Savings (Fuel Water Heating Only)

$$\Delta MMBtu = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{1{,}000{,}000} \times \frac{1}{E_{t,fuel}} \times ESF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
units	= Number of measures installed under the program
GPD	= Gallons per day
ΔT_{main}	= Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	= Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
UA	= Overall heat loss coefficient (BTU/h-°F)
ESF	= Energy savings factor
E_t	= Water heater thermal efficiency
CF	= Coincidence factor
365	= Days in one year

8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kWh equals 3,412 BTU
1,000,000 = Conversion factor, one MMBtu equals 1,000,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPD		From application, or lookup/calculate based on building type, square footage and occupancy from GPD table below.
ΔT_{main}	$T_{set} - T_{main}$	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	$= T_{set} - T_{amb}$	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F).
T_{set}		From application.
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
T_{amb}	70	Surrounding ambient air temperature (°F).[72]
$E_{t,elec}$	0.98	From application. If unknown, use default thermal efficiency of typical electric storage type water heater provided.[73]
$E_{t,fuel}$	0.80	From application. If unknown, use default efficiency of typical gas storage type water heater.[74]
UA	7.85	Overall heat loss coefficient of the baseline condition (BTU/h-°F).[75]
ESF	0.25	Oak Ridge National Laboratory. [76]
CF	0.8	

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate and are approximately equal to the

[72] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.
[73] Per 10 CFR 431 Subpart G, Appendix B 5.7.1
[74] Per 10 CFR 431.110 (a)
[75] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was equated for two minimally code compliant gas storage water heaters found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 BTU/h assumed) and between 55 and 120 gallon capacity (75 gallon, 76,000 BTU/h assumed). Results of heat loss coefficient evaluation at these two data points agreed to within 0.3%, so the lower of the two was selected to represent the $UA_{baseline}$ term.
[76] GFX Evaluation, Oak Ridge National Laboratory, August 2000, lower end of the energy savings range (25-30%). Savings are assumed to be comparable to residential application.

annual average outdoor temperature plus 6°F.[77] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[78] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Gallons per Day (GPD)

The average daily hot water usage, expressed in gallons per day, for several commercial facility types is tabulated below. Daily hot water usage can be calculated based on the GPD and site-specific metric in the Rate column, or default values can be referenced directly from the GPD column.

Building Type	GPD	Rate	Notes/Assumptions	Source
Assembly	239	7.02 GPD per 1,000 SF	Assumes 10% hot water, 34,000 SF	EIA[79]: Public Assembly
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 10% hot water, 5,150 SF	EIA: Other
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 10% hot water, 130,500 SF	EIA: Mercantile
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL[80]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation[81]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC[82]: Quick Service
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service
Grocery	172	3.43 GPD per 1,000 SF	Assumes 10% hot water, 50,000 SF	EIA: Mercantile
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 40% hot water, 250,000 SF	EIA: Health Care, Inpatient
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 10% hot water, 130,000 SF	EIA: Mercantile
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 10% hot water, 100,000 SF	EIA: Other
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 40% hot water, 30,000 SF	EIA: Lodging
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 10% hot water, 92,000 SF	EIA: Warehouse and Storage
Religious	77	7.02 GPD per 1,000 SF	Assumes 10% hot water, 11,000 SF	EIA: Public Assembly
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 10% hot water, 8,000 SF	EIA: Mercantile
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 10% hot water, 500,000 SF	EIA: Warehouse and Storage
Other	Calculate	4.89 GPD per 1,000 SF	Assumes 10% hot water	EIA: Other

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

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

[79] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012

[80] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011

[81] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016

[82] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[83]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a storage type water heater without a DWHR system in a commercial application.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a storage type water heater equipped with DWHR on the main waste drainage line in a commercial application. DWHR units shall comply with CSA B55.2 and shall be tested in accordance with CSA B55.1. Potable water-side pressure loss of DWHR units shall be less than 3 psi.[84]

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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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[83] *No source specified – update pending availability and review of applicable references.*
[84] ECCCNYS 2020, Section R403.5.4 Drain Water Recovery Units

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MOTORS AND DRIVES

PEI-RATED CLEAN WATER PUMP

Measure Description

The measure covers the installation of constant and variable speed PEI-rated clean water pumps in agricultural, commercial, industrial and municipal environments. PEI-rated clean water pumps refer to clean water pumps rated using the Pump Energy Index (PEI), a metric established by the DOE to rate pump efficiency.[85] As a rating, PEI refers to the ratio of a pump's energy rating divided by the energy rating of a minimally compliant pump with lower PEI indicating greater efficiency. As of January 27, 2020, all clean water pumps between 1 and 200 hp are required to have a PEI rating less than 1.0. Circulator pumps, pool pumps, fire pumps and magnet driven pumps fall outside of the scope of this measure. [86]

The PEI rated clean water pumps category consists of five pump types: Radially Split Multi-Stage Vertical In-Line Diffuser Casing (RSV), Vertical Submersible Turbine (ST), End Suction Close Coupled (ESCC), In-Line (IL) and End Suction Frame Mount (ESFM).Each pump type is further broken into constant and variable speed models. Pumps are generally offered with either 1800 RPM or 3600 RPM (nominal) motors.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = hp \times 0.746 \times (1 - OF) \times (PEI_{baseline} - PEI_{ee}) \times LSAF \times hrs$$

Summer Peak Coincident Demand Savings

$$\Delta kW = hp \times 0.746 \times RLF \times (PEI_{baseline} - PEI_{ee}) \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
hp	= Pump motor horsepower
OF	= Oversize Factor
ee	= Energy efficiency condition or measure
baseline	= Baseline condition or measure
PEI	= Pump Energy Index
LSAF	= Load Shape Adjustment Factor

[85] 10 CFR 431.464 Appendix A
[86] 10 CFR 431.465

hrs = Annual hours of operation
RLF = Rated load factor
CF = Coincidence factor
0.746 = Conversion factor (kW/hp), 746 watts equals one horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application.
OF		Average amount of equipment oversizing. Lookup from Oversize Factor table below based on speed control case and motor hp.
$PEI_{baseline}$		See Baseline Efficiency section below.
PEI_{ee}		From application
LSAF		Lookup from Load Shape Adjustment Factor table below based on application and speed control case.
hrs		From application. If unknown, see Operating Hours section below for default values by building sector.
RLF	0.75	Ratio of the peak motor load to the maximum connected load.[87, 88]
CF	0.8	

Oversize Factor[89]

Speed Control Case	Motor Size Range		Oversize Factor
	Min. HP	Max. HP	
Constant Speed	1	4.9	0.37
	5	9.9	0.31
	10	24.9	0.26
	25	49.9	0.24
	50	99.9	0.20
	100	200	0.17
Variable Speed	1	1.9	0.37
	2	2.9	0.37
	3	4.9	0.37
	5	9.9	0.31
	10	24.9	0.26
	25	49.9	0.24
	50	99.9	0.20
	100	200	0.17

87 U.S. DOE, Determining Electric Motor Load and Efficiency, p. 1; assumes system is designed to maximize efficiency.
88 RLF value assumed for PEI pumps is under review and will be revised when a substantiating reference has been identified.
89 Regional Technical Forum, Efficient Pumps v2.0, Parameters worksheet, row 15

Load Shape Adjustment Factor, by application and speed control case[90]

Application	Constant Speed	Variable Speed
Agricultural	1.325	1.845
Commercial	1.250	1.000
Industrial	1.310	1.214
Municipal	0.840	0.990

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[91]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a pump with a high PEI rating. The baseline PEI rating for constant speed pumps is 1.0 per federal requirements.[92] Baseline PEI values for variable speed pumps are based on the table below. Savings for variable speed pumps installed in new construction projects may be calculated using the constant speed pump baseline if code does not require a variable speed pump.

The PEI rated clean water pumps category consists of five pump types: Radially Split Multi-Stage Vertical In-Line Diffuser Casing (RSV), Vertical Submersible Turbine (ST), End Suction Close Coupled (ESCC), In-Line (IL) and End Suction Frame Mount (ESFM).

Variable Speed Baseline PEI[93]

Pump Type	Motor Speed (RPM)	Pump Motor hp							
		1 to 1.9 hp	2 to 2.9 hp	3 to 4.9 hp	5 to 9.9 hp	10 to 24.9 hp	25 to 49.9 hp	50 to 99.9 hp	100 to 200 hp
RSV	1800	0.55	0.55	0.52	0.50	0.49	0.48	0.47	0.48
ST	1800	0.61	0.60	0.58	0.56	0.55	0.55	0.53	0.54
ESCC	1800	0.54	0.52	0.50	0.49	0.47	0.46	0.46	0.45
IL	1800	0.54	0.53	0.51	0.50	0.48	0.47	0.47	0.47
ESFM	1800	0.49	0.53	0.50	0.49	0.47	0.46	0.46	0.45
RSV	3600	0.56	0.55	0.53	0.52	0.50	0.49	0.48	0.48
ST	3600	0.60	0.59	0.57	0.55	0.55	0.54	0.53	0.53
ESCC	3600	0.53	0.52	0.54	0.48	0.45	0.44	0.45	0.44
IL	3600	0.54	0.54	0.54	0.50	0.46	0.46	0.47	0.46
ESFM	3600	0.53	0.52	0.50	0.49	0.47	0.47	0.47	0.47

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a constant speed pump with a PEI rating less than 0.96 or a variable speed pump with a PEI rating less than 0.49 or the corresponding baseline PEI, whichever is lower.

[90] Regional Technical Forum, Efficient Pumps v2.0, Parameters worksheet rows 30-35
[91] *No source specified – update pending availability and review of applicable references.*
[92] 10 CFR 431.465
[93] Regional Technical Forum, Efficient Pumps v2.0, PEI_CL to PEI_VL worksheet, row 83.

Operating Hours

Annual operating hours shall come from application. If actual operating hours are unknown, the values in the table below per RTF analysis and NEEA research shall be used as defaults. The default operating hours below were determined from the NEEA research from metering of existing and newly installed pumps in the field across the sectors specified.[94]

Sector	Operating Hours
Agricultural	2,358
Commercial	3,753
Industrial	6,175
Municipal	3,360

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

References

1. 10 CFR 431.464 - Test procedure for the measurement of energy efficiency, energy consumption, and other performance factors of pumps
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=fa8761ce7ff31d0c22aaf4e1c4992575&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1464
2. 10 CFR 431.465 - Pumps energy conservation standards and their compliance dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=fa8761ce7ff31d0c22aaf4e1c4992575&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1464
3. U.S. DOE, Determining Electric Motor Load and Efficiency
   Available from: https://energy.gov/sites/prod/files/2014/04/f15/10097517.pdf
4. Regional Technical Forum, Efficient Pumps v2.0
   Available from: https://nwcouncil.app.box.com/v/EfficientPumpsv2-0

[94] Extended Motor Products Savings Validation Research on Clean Water Pumps and Circulators, Northwest Energy Efficiency Alliance.

5. Extended Motor Products Savings Validation Research on Clean Water Pumps and Circulators, Northwest Energy Efficiency Alliance.
Available from: https://neea.org/resources/extended-motor-products-savings-validation-research-on-clean-water-pumps-and-circulators

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3-21-15	4/14/2021

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HIGH EFFICIENCY TRANSFORMER

Measure Description

This measure covers the installation of new electric transformers (i.e. not refurbished equipment) exceeding codes and standards required efficiency in commercial and industrial applications. These transformers are used to step down power from distribution voltage to serve HVAC, process and plug loads in commercial and industrial facilities.

This measure is only applicable to low-voltage dry-type distribution transformers, liquid-immersed distribution transformers, and medium-voltage dry-type distribution transformers installed behind the meter, for which minimum federal efficiency standards are defined.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = kVA \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) \times LF \times PF \times hrs$$

Summer Peak Coincident Demand Savings

$$\Delta kW = kVA \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) \times LF \times PF \times CF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fuel energy savings
kVA = Power rating of the transformer, in kVA
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
Eff = Efficiency rating of transformer (must be entered as a decimal value)
PF = Power Factor, ratio of real power to apparent power supplied to the transformer
LF = Load Factor, ratio of average annual transformer load to peak load rating
hrs = Annual operating hours
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
kVA		From application.
$Eff_{baseline}$		Lookup based on transformer type, phase and kVA rating in Baseline Efficiency section below.
Eff_{ee}		From application.
LF		From application. Can be approximated as total annual facility kWh consumption divided by the product of transformer kVA rating and 8,760.
PF		From application. If unavailable, use 1.0 as default.[95]
hrs		From application. If unknown, use 8,760.
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[96]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a minimally code compliant commercial transformer of type and kVA rating equivalent to the efficient equipment.

Low-Voltage Dry-Type Distribution Transformers.[97,98]

The baseline efficiency for low-voltage dry-type distribution transformers shall be established based on phase and kVA rating from the table below. Low-voltage dry-type distribution transformers with kVA ratings not appearing in the table shall have their minimum efficiency level determined by linear interpolation of the kVA and efficiency values immediately above and below that kVA rating.

Single-phase		Three-phase	
kVA	**Efficiency (%)**	**kVA**	**Efficiency (%)**
15	97.70	15	97.89
25	98.00	30	98.23
37.5	98.20	45	98.40
50	98.30	75	98.60
75	98.50	112.5	98.74
100	98.60	150	98.83
167	98.70	225	98.94
250	98.80	300	99.02
333	98.90	500	99.14
		750	99.23
		1,000	99.28

[95] Default unity power factor as used in the test procedures provided by US DOE. Energy Conservation Program: Test Procedures for Distribution Transformers; Final Rule. Effective May 30, 2006.
[96] Coincidence factor for distribution transformers is 1.0 by definition.
[97] 10 CFR 431.196(a)(2)
[98] ECCCNYS 2020, Table C405.6

Liquid-Immersed Distribution Transformers[99]

The baseline efficiency for liquid-immersed distribution transformers shall be established based on phase and kVA rating from the table below. Liquid-immersed distribution transformers with kVA ratings not appearing in the table shall have their minimum efficiency level determined by linear interpolation of the kVA and efficiency -values immediately above and below that kVA rating.

Single-phase		Three-phase	
kVA	**Efficiency (%)**	**kVA**	**Efficiency (%)**
10	98.70	15	98.65
15	98.82	30	98.83
25	98.95	45	98.92
37.5	99.05	75	99.03
50	99.11	112.5	99.11
75	99.19	150	99.16
100	99.25	225	99.23
167	99.33	300	99.27
250	99.39	500	99.35
333	99.43	750	99.40
500	99.49	1000	99.43
667	99.52	1500	99.48
833	99.55	2000	99.51
		2500	99.53

Medium-Voltage Dry-Type Distribution Transformers[100]

The baseline efficiency for a medium-voltage dry-type distribution transformer shall be established based on phase, BIL and kVA rating from the table below. Medium-voltage dry-type distribution transformers with kVA ratings not appearing in the table shall have their minimum efficiency level determined by linear interpolation of the kVA and efficiency values immediately above and below that kVA rating.

[99] 10 CFR 431.196(b)(2)
[100] 10 CFR 431.196(c)(2)

Single-phase				Three-phase			
kVA	BIL*			kVA	BIL		
	20-45 kV	46-95 kV	≥96 kV		20-45 kV	46-95 kV	≥96 kV
	Efficiency (%)	Efficiency (%)	Efficiency (%)		Efficiency (%)	Efficiency (%)	Efficiency (%)
15	98.10	97.86		15	97.50	97.18	
25	98.33	98.12		30	97.90	97.63	
37.5	98.49	98.30		45	98.10	97.86	
50	98.60	98.42		75	98.33	98.13	
75	98.73	98.57	98.53	112.5	98.52	98.36	
100	98.82	98.67	98.63	150	98.65	98.51	
167	98.96	98.83	98.80	225	98.82	98.69	98.57
250	99.07	98.95	98.91	300	98.93	98.81	98.69
333	99.14	99.03	98.99	500	99.09	98.99	98.89
500	99.22	99.12	99.09	750	99.21	99.12	99.02
667	99.27	99.18	99.15	1,000	99.28	99.20	99.11
833	99.31	99.23	99.20	1,500	99.37	99.30	99.21
				2,000	99.43	99.36	99.28
				2,500	99.47	99.41	99.33

*BIL = Basic impulse insulation level

Note: All efficiency values are at 50 percent of nameplate rated load, determined according to the DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A to Subpart K of 10 CFR part 431.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a new electric transformer exceeding codes and standards required efficiency . The efficiency of the compliant equipment must exceed the efficiency of the baseline equipment.

Operating Hours

Operating hours shall come from application. If transformer operating hours are unknown, use 8,760 as default.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Installation of high efficiency transformers reduces waste heat, which impacts heating loads when this equipment is installed in conditioned spaces. These effects are not quantified in the prescribed savings estimation methodology for this measure at this time.

Ancillary Electric Savings Impacts

Installation of high efficiency transformers reduces waste heat, which impacts heating loads when this equipment is installed in conditioned spaces. These effects are not quantified in the prescribed savings estimation methodology for this measure at this time.

References

1. 10 CFR Part 431 Docket No. EE -TP-98-550, Energy Conservation Program: Test Procedures for Distribution Transformers
   Available from: https://www.govinfo.gov/content/pkg/FR-2006-04-27/pdf/06-3165.pdf
2. 10 CFR 431.196: Appendix A to Subpart K for Measuring the Energy Consumption of Distribution Transformer
   Available here: https://www.ecfr.gov/cgi-bin/text-idx?SID=cfc3276c3d076eb67bbf51af135e2a9c&mc=true&node=sp10.3.431.k&rgn=div6#se10.3.431_1196
3. ECCCNYS 2020, Table C405.6 Minimum Nominal Efficiency Levels for 10 CFR 431 Low-Voltage Dry-Type Distribution Transformers.
   Available here: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency

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3-21-16	4/14/2021

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HIGH FREQUENCY BATTERY CHARGER

Measure Description

This measure covers the installation of high frequency battery chargers replacing existing ferroresonant, SCR (silicon-controlled rectifier) or hybrid charging technology. Industrial high-frequency battery chargers are used for portable industrial equipment like forklifts and airport transport equipment in factories, warehouses and similar facilities. They convert standard AC power to DC power stored in batteries. System inefficiencies occur during charging, charge maintenance and standby.

This measure is only applicable to high frequency battery chargers with a rated input power of more than 2 kW and may be single phase or three phase. This measure does not apply to vehicle chargers or smaller chargers like those used for golf carts.

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left\{ Cap \times DOD \times Charge_{year} \times \left(\frac{CRF_{baseline}}{PCE_{baseline}} - \frac{CRF_{ee}}{PCE_{ee}} \right) + \left[\frac{\left(W_{MM,baseline} \times hrs_{MM}\right) + \left(W_{NBM,baseline} \times hrs_{NBM}\right)}{1{,}000} - \frac{\left(W_{MM,ee} \times hrs_{MM}\right) + \left(W_{NBM,ee} \times hrs_{NBM}\right)}{1{,}000} \right] \right\} \times (1 + HVAC_c)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{PF_{baseline}}{PCE_{baseline}} - \frac{PF_{ee}}{PCE_{ee}} \right) \times V \times \frac{A}{1{,}000} \times CF \times (1 + HVAC_d)$$

Annual Fuel Energy Savings

$$\Delta MMBtu = \left\{ Cap \times DOD \times Charge_{year} \times \left(\frac{CRF_{baseline}}{PCE_{baseline}} - \frac{CRF_{ee}}{PCE_{ee}} \right) + \left[\frac{\left(W_{MM,baseline} \times hrs_{MM}\right) + \left(W_{NBM,baseline} \times hrs_{NBM}\right)}{1{,}000} - \frac{\left(W_{MM,ee} \times hrs_{MM}\right) + \left(W_{NBM,ee} \times hrs_{NBM}\right)}{1{,}000} \right] \right\} \times HVAC_{ff}$$

where:

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
ΔMMBtu = Annual fuel energy savings
Cap = Nameplate capacity of battery (in kWh)
DOD = Depth of discharge
$Charge_{year}$ = Number of charging cycles per year
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
CRF = Charge return factor, the ratio of energy out of the battery versus the energy into the battery.
PCE = Power conversion efficiency, the ratio of energy out of charger to the energy into charger
W_{MM} = Power in maintenance mode, when connected battery is fully charged (watts)
W_{NBM} = Power used by charger when no battery is connected (watts)
hrs_{MM} = Hours per year in maintenance mode
hrs_{NBM} = Hours per year in no battery mode
PF = Power factor of charger
V = Charger nameplate volts
A = Charger nameplate amps
$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor at utility summer peak hour
$HVAC_{ff}$ = HVAC interaction factor for annual fossil fuel consumption (MMBtu/kWh)
3.412 = Conversion factor, one watt-hour equals 3.412 BTU
1,000 = Conversion factor, one kW equals 1,000 watts
CF = Coincidence Factor

Summary of Variables and Data Sources

Variable	Value	Notes
Cap		From application. If unknown, use 35 kWh.[101]
DOD		From application. If unknown, use 0.80.[102]
$Charge_{year}$		From application. If unknown, lookup in Number of Charges Per Year table below based on facility operation.
$CRF_{baseline}$		Lookup based on existing equipment type in Baseline Efficiencies section below.
$PCE_{baseline}$		Lookup based on existing equipment type in Baseline Efficiencies section below.
CRF_{ee}		From application. If unknown, lookup in Compliance Efficiency section below.
PCE_{ee}		From application. If unknown, lookup in Compliance Efficiency section below.

[101] Jacob V. Renquist, Brian Dickman, and Thomas H. Bradley: "Economic Comparison of fuel cell powered forklifts to battery powered forklifts", International Journal of Hydrogen Energy Volume 37, Issue 17, (2012)
[102] Emerging Technologies Program Application Assessment Report #0808, Industrial Battery Charger Energy Savings Opportunities, Pacific Gas & Electric. May 29, 2009

Variable	Value	Notes
$W_{MMbaseline}$		Lookup based on existing equipment type in Baseline Efficiencies section below.
$W_{NBM,baseline}$		Lookup based on existing equipment type in Baseline Efficiencies section below.
$W_{MM,ee}$		From application. If unknown, lookup in Compliance Efficiency section below.
$W_{NBM,ee}$		From application. If unknown, lookup in Compliance Efficiency section below.
$PF_{baseline}$		Lookup based on existing equipment type in Baseline Efficiency section below.
PF_{ee}		Lookup in Compliance Efficiency section below.
V		From application. If unknown, use 48 volts.[103]
A		From application. If unknown, use 81 amps.[104]
hrs_{NBM}		From application.
hrs_{MM}		From application.
$HVAC_c$	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 Spaces: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_{ff}$	Exterior and Unconditioned Spaces: 0	HVAC interaction factor for annual fuel energy consumption (MMBtu/kWh), from Appendix D based on facility type, location and HVAC type.
CF	0 for single and 2-shift, 1.0 for 3-shift and 4-shift.	

[103] Ibid. Voltage rating based on the assumption of 35 kWh battery with a normalized average amp-hour capacity of 760 Ah charged over a 7.5 hour charge cycle.
[104] Ibid. Ampere rating based on the assumption of 35 kWh battery with a normalized average amp-hour capacity of 760 Ah charged over a 7.5 hour charge cycle

Number of Charges Per Year

Facility Operating Schedule (hours per day / days per week)	Number of Charges Per Year[105]
Single Shift 7AM – 3 PM, weekdays	260
Two Shifts 7AM – 11 PM, weekdays	520
Three Shifts 24 hours per day, weekdays	780
Four Shifts or Continual Operation 24 hours per day, 7 days a week	1,092

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.0 for single shift and two shift and 1.0 for three and forth shift.[106]

Baseline Efficiencies from which Energy Savings are Calculated

The baseline condition is a ferroresonant, SCR or hybrid battery charger with a minimum of single shift operation as shown in the table below.[107]

Equipment Type	$CRF_{baseline}$	$PCE_{baseline}$	$W_{MM, baseline}$	$W_{NBM, baseline}$	$PF_{baseline}$
Ferroresonant	1.15	0.85	81.7	18.2	0.92
SCR	1.18	0.85	137.1	125.3	0.76
Hybrid	1.12	0.86	62.3	14.1	0.91
Unknown	1.16	0.85	99.9	55.4	0.86

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a high frequency battery charger with a minimum 8-hour shift operation five days per week, with CRF, PCE and PF meeting or exceeding and W_{MM} and W_{NBM} at or below the values shown in the table below.[108]

Equipment Type	CRF_{ee}	PCE_{ee}	$W_{MM,ee}$	$W_{NBM,ee}$	PF_{ee}
High Frequency	1.15	0.92	48.4	48.4	0.96

[105] Values are based on an estimated one charge per 8-hour shift.
[106] Emerging Technologies Program Application Assessment Report #0808, Industrial Battery Charger Energy Savings Opportunities, Pacific Gas & Electric. May 29, 2009
[107] Field Study of Industrial High Frequency Battery Chargers, MN Department of Commerce, pg 11. The 'unknown' baseline equipment type is derived as a weighted average of ferroresonant, SCR and hybrid batteries. The population fraction was derived from Table 1 of the MN study.
[108] Ibid.

Operating Hours

Annual operating hours are embedded in number of charges per year term and shall come from application or shall be based on facility operating schedule. Annual maintenance mode and no battery mode hours shall come from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Ancillary effects are captured in the prescribed methodology detailed above. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

Ancillary Electric Savings Impacts

Ancillary effects are captured in the prescribed methodology detailed above. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

References

1. Emerging Technologies Program Application Assessment Report #0808, Industrial Battery Charger Energy Savings Opportunities, Pacific Gas & Electric. May 29, 2009 Available from: https://www.etcc-ca.com/reports/forklift-battery-charger?dl=1607628531
2. Jacob V. Renquist, Brian Dickman, and Thomas H. Bradley: "Economic Comparison of fuel cell powered forklifts to battery powered forklifts", International Journal of Hydrogen Energy Volume 37, Issue 17, (2012)
3. Field Study of Industrial High Frequency Battery Chargers, September 8, 2017. Minnesota Department of Commerce, Division of Energy Resources. Available from: https://www.cards.commerce.state.mn.us/CARDS/security/search.do?documentId=%7b7849AB55-DFC6-4F87-AC80-BD0356BB32D9%7d

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3-21-17	4/14/2021

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APPENDIX P

EFFECTIVE USEFUL LIFE (EUL)

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance	Air Purifier	Residential	9	ENERGY STAR® Calc[109]
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[110]
	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Dehumidifier	Residential	12	ENERGY STAR® Calc[111]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Fireplace	Residential	15	DOE[112]
	Refrigerator and Freezer	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[113]
Appliance Control	Advanced Power Strip (APS)	Residential	8	DEER 2014 EUL ID: Plug-OccSens
Appliance Recycling	Air Conditioner - Room (RAC) Recycling	Residential	3	DEER 2014 EUL ID: HV-RAC-RUL
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef
	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr

[109] 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
[110] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[111] ENERGY STAR® Dehumidifier Calculator https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls
[112] 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
[113] 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
Building Shell	Air Conditioner – Room (RAC) Cover and Gap Sealer	Residential	5	See note below[114]
	Air Leakage Sealing	Residential	15	GDS[115]
	Insulation – Hot Water and Steam Pipe	Residential	15	GDS[116]
	Insulation – Opaque Shell	Residential	25	GDS[117]
	Storm Window	Residential	20	DOE[118]
	Window	Residential	20	DEER 2014 EUL ID: BS-Win
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[119]
	Storage Water Heater - Electric	Residential	13	DEER 2014 EUL ID: WtrHt-Res-Elec
	Instantaneous Water Heater	Residential	20	DEER 2014 EUL ID: WtrHt-Instant-Res
	Solar Pool Heater	Residential	15	DOE[120]
DHW - Control	Drain Water Heat Recovery (DWHR)	Residential	30	2019 Title 24[121]
	Low-Flow – Faucet Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow – Showerhead	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Thermostatic Shower Restriction Valve	Residential	10	UPC[122]

[114] At least one manufacturer's warranty period. www.gss-ee.com/products.html
[115] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[116] Ibid.
[117] Ibid.
[118] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf
[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] https://www.energy.gov/energysaver/solar-swimming-pool-heaters
[121] 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
[122] 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[123]
	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[124]
	Boiler and Furnace - Combination ("Combi") Furnace	Residential	20	DEER 2014[125] 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
	Energy and Heat Recovery Ventilator	Residential	14	PA Consulting Group[126]

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

[124] 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

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

[126] 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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Furnace, Gas Fired	Residential	22	DOE[127, 128]
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[129]
	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
	Steam Trap – Low Pressure Space Heating	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[130]
	Thermostat – All Types	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats

[127] 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

[128] 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

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

[130] NYSERDA Residential Electric Submetering Manual

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
HVAC - Control	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[131]
	Smart Thermostatic Radiator Enclosure	Residential	15	DEER 2014 EUL ID: Motors-fan[132]
Lighting	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[133]
			50,000 hours	DLC[134]

[131] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. pg. 16
[132] Based on assumed EUL of integrated fan, which is expected to be the first component to fail
[133] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, p. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf
[134] Placed on the Qualified Products List by the Design Light Consortium (DLC) 50,000 hours, according to the appropriate Application Category as specified in the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4 or higher

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED (Interior)	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	ENERGY STAR® Fixtures[135]
		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
		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[136]

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

[136] 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

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	Pool Heater	Residential	8	DOE [137]

[137] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75 Available from: https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170

Commercial and Industrial Measures

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment	High Speed Fans	C&I	10	PG&E[138]
	Milk Pre-Cooler Heat Exchanger	C&I	15	PA Consulting Group[139]
	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[140]
	Variable Speed Drive Milk Pump Plate Cooler	C&I	15	PA Consulting Group[141]
	Variable Speed Drive Vacuum Pump	C&I	15	PA Consulting Group[142]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[143]
	Clothes Washer	C&I	11	DEER 2014 EUL ID: Appl-EffCW
	Cooking Equipment[144]	C&I	12	DEER 2014 EUL IDs: Various
	Dishwasher	C&I	10 – Under Counter 15 – Single Door 20 – Conveyor Type 10 – Pots, Pans & Utensils	ENERGY STAR®Calc[145]
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
	Refrigerator and Freezer	C&I	12	DEER 2014 EUL ID: Cook-SDRef
Appliance - Control	Advanced Power Strip (APS)	C&I	8	DEER 2014 EUL ID: Plug-OccSens
	Vending Machine and Novelty Cooler Control	C&I	5	DEER 2014 EUL ID: Plug-VendCtrler

[138] PG&E Work Paper PGE3PAGR117, October 12, 2017
[139] 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
[140] Based on EUL's for Advanced Power Strips
[141] 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
[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] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[144] Applicable to all kitchen cooking equipment not otherwise listed
[145] ENERGY STAR® Savings Calculator for ENERGY STAR® Certified Commercial Kitchen Equipment www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx?5da4-3d90&5da4-3d90

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Appliance Recycling	Air Conditioner – Room (RAC)	C&I	9	DEER 2014 EUL ID: HV-RAC-ES
Building Shell	Air Leakage Sealing	C&I	15	GDS[146]
	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Insulation - Hot Water and Steam Pipe	C&I	15	GDS[147]
	Insulation - Opaque Shell	C&I	30	ET & CEC[148]
	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[149]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[150]
	No Air Loss Water Drain	C&I	13	MA Measure Life Study[151]
	Refrigerated Air Dryer	C&I	13	Other State TRMs [152]
	Compressed Air Heat Recovery	C&I	13	Other State TRMs [153]
	Flow Controller	C&I	13	Other State TRMs [154]
	Low Pressure Drop Filter	C&I	5	Other State TRMs [155]
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

[146] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[147] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[148] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[149] 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.
[150] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission
[151] 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
[152] 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.
[153] Ibid.
[154] Ibid.
[155] Ibid.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
DHW - Control	Drain Water Heat Recovery (DWHR)	C&I	30	2019 Title 24[156]
	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[157]
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[158]
	Boiler and Furnace - Combination ("Combi") Furnace	C&I	20	DEER 2014[159] EUL ID: HVAC-Frnc
	Boiler, Hot Water – Steel Water Tube	C&I	24	ASHRAE Handbook, 2015
	Boiler, Hot Water – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Hot Water – Cast Iron	C&I	35	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Water Tube	C&I	30	ASHRAE Handbook, 2015
	Boiler, Steam – Steel Fire Tube	C&I	25	ASHRAE Handbook, 2015
	Boiler, Steam – Cast Iron	C&I	30	ASHRAE Handbook, 2015
	Chiller – Air & Water Cooled	C&I	20	DEER 2014 EUL ID: HVAC-Chlr
	Chiller – Cooling Tower	C&I	15	DEER 2014 EUL ID: HVAC-ClTwrPkgSys
	Condensing Unit Heater	C&I	18	Ecotope[160]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	Electronically Commutated (EC) Motor - HVAC Blower Fan	C&I	15	DEER 2014 EUL ID: Motors-Fan

[156] 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
[157] https://www.nrel.gov/docs/fy16osti/64541.pdf
[158] 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
[159] Based on DEER value for high efficiency boiler and instantaneous water heater
[160] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	Electronically Commutated (EC) Motor – Hydronic Circulator Pump	C&I	15	DEER 2014 EUL ID: Motors-pump
	Economizer –Dual Enthalpy Air Side	C&I	10	DEER 2014 EUL ID: HVAC-addEcono
	Furnace, Gas Fired	C&I	23	DOE [161, 162]
	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 [163]
	High Volume Low Speed Fan	C&I	15	PA Consulting Group [164]
	Infrared Heater	C&I	17	GDS [165]
	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 [166]
	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

[161] 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

[162] 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

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

[164] 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

[165] 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

[166] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
HVAC – Control	Adaptive Photonic Control	C&I	EUL = Retrofitted motor RUL = Retrofitted motor EUL – (Current Year – Mfr. Year) **Default = 5**	DEER 2014 EUL ID: Motors-fan
	Direct Digital Control (DDC) System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Demand Control Ventilation (DCV)	C&I	15	DEER 2014 EUL ID: HVAC-VSD-DCV
	Energy Management System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Energy Management System – Guest Room	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Boiler Economizer	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	GDS [167]
	Kitchen Demand Ventilation Control	C&I	15	PG&E [168]
	Outdoor Temperature Setback Control for Hydronic Boiler	C&I	EUL = Boiler RUL = Boiler EUL – (Current Year – Mfr. Year) **Default = 5**	N/A
	Steam Trap – Low-Pressure Space Heating	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Thermostat – Programmable Thermostat – Wi-Fi (Communicating)	C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve	C&I	15	DOE [169]
	Advanced Rooftop Control	C&I	EUL = RUL of Existing RTU = RTU EUL – (Current Year – Year of Mfr.) **Default = 5**	N/A

[167] 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
[168] PG&E Work Paper WPSDGENRCC0019, June 15, 2012
[169] U.S. DOE. "Thermostatic Radiator Valve Evaluation." January 2015. Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf

Category	Commercial & Industrial Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED Fixture (DLC)	C&I	50,000 hrs /annual lighting operating hrs or 15 yrs if annual operating hrs are not known	DLC[170]
Lighting	Light Fixture	LED Fixture (Interior)	C&I	Rated Life listed by ENERGY STAR or default to 25,000 hrs/annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®[171]
		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®[172]
		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®[173]
		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

[170] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.4

[171] 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

[172] 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

[173] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.1. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	LED Lamp	C&I	50,000 hours	DLC[174]
			Rated Life listed by ENERGY STAR or default to 15,000 hrs /annual lighting operating hrs or 15 yrs if rated lifetime or annual operating hrs are not known	ENERGY STAR®
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
	Lighting Power Density (LPD)	C&I	15	GDS[175]
Lighting - Control	Bi-Level Lighting	C&I	15	ComEd[176]
	Integrated Interior Lighting Control	C&I	15	ComEd[177]
	Non-Integrated Interior Lighting Control	C&I	10	GDS[178]
	Plug-Load Occupancy Sensor	C&I	8	DEER[179]
Motors and Drives	Motor (incl. PEI Pumps)	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Notched & Synchronous Belt	C&I	5	DEER 2014 EUL ID: HV-CoggedBelt
	Pool Pump	C&I	10	DEER 2014 EUL ID: OutD-PoolPump
	Variable Frequency Drive (VFD) – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
	Elevator Modernization	C&I	15	DEER 2014[180]

[174] 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

[175] 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

[176] 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

[177] 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

[178] 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

[179] DEER value for lighting occupancy sensors

[180] Assumes same EUL as VFD measure.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Other	High Efficiency Transformer	C&I	32	DOE[181]
	High Frequency Battery Charger	C&I	15	PG&E[182]
	Pool Heater	C&I	8	DOE[183]
Process Equipment	Steam Trap – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
	Ozone Laundry	C&I	10	PG&E[184]
	Process Exhaust Filtration	C&I	15	CIBSE[185]
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
	Electronically Commutated (EC) Motor – Refrigerated Case or Walk-In Cooler/Freezer Evaporator Fan	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	Equipment (Condenser, Compressor, and Sub-cooling)	C&I	15	DEER 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

[181] https://www.federalregister.gov/documents/2019/06/18/2019-12761/energy-conservation-program-energy-conservation-standards-for-distribution-transformers
[182] https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf, pg 43
[183] 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
[184] PG&E Work Paper PGECOAPP123, August 22, 2017
[185] Chartered Institution of Building Services Engineers. "Probabilistic Estimation of Service Life." An industrial ventilation system consists of a fan and a set of filters; Fan and Filter EUL are 15 to 20 years depending on type. http://www.cibse.org/knowledge/cibse-technical-symposium-2011/probabilistic-estimation-of-service-life.

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Condenser Pressure and Temperature Control	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Floating Head Pressure Control	C&I	10	PA Consulting Group [186]

Common References

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

Record of Revision

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

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

Record of Revision Number	Issue Date
12-19-17	12/23/2019
3-20-17	3/30/2020
7-20-20	7/31/2020
12-20-12	12/31/2020
3-21-18	4/14/2021

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