New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –

Residential, Multi-Family, and Commercial/Industrial Measures

Version 6.1

Issue Date – January 31, 2019
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New York State Joint Utilities

Version History of the New York State Technical Resource Manual:

Version	Title	Issued
n/a	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Selected Residential and Small Commercial Measures (Electric)*	12/28/2008
n/a	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Gas)** – *Selected Residential and Small Commercial Gas Measures*	3/25/2009
n/a	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Multi-family Programs**	7/9/2009
n/a	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial Industrial Programs**	9/1/2009
n/a	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Single Family Residential Measures*	12/16/2009
1	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	10/15/2010
2	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	12/10/2014
3	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	6/1/2015
4	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	4/29/2016
5	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	7/17/2017
5.1	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	3/15/2018

5.2	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	4/10/2018
6	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	4/16/2018
6.1	**New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –** *Residential, Multi-family, and Commercial/Industrial Measures*	1/31/2019

Acknowledgements The *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multi-family, and Commercial/Industrial Measures*, Version 6.1, dated January 31, 2019, was updated by the Technical Resource Manual Management Committee lead by the Joint Utilities[1] in consultation with New York State Department of Public Service. In accordance with the Commission's February 26, 2015 Order in Case 14-M-0101 – Proceeding on the Motion of the Commission in Regard to Reforming the Energy Vision, Staff has transferred this document to the Joint Utilities as of June 1, 2015 to support the Joint Utilities in assuming responsibility for the ongoing maintenance of the Technical Resource Manual.

[1] Central Hudson Gas and Electric Corporation ("Central Hudson"), Consolidated Edison Company of New York, Inc. ("Con Edison"), National Fuel Gas Distribution Corporation ("National Fuel"), New York State Electric & Gas Corporation ("NYSEG"), Niagara Mohawk Power Corporation d/b/a National Grid, The Brooklyn Union Gas Company d/b/a National Grid NY and KeySpan Gas East Corporation d/b/a National Grid (collectively "National Grid"), Orange and Rockland Utilities, Inc. ("O&R"), and Rochester Gas and Electric Corporation ("RG&E")

Table of Revisions/Changes

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-1	R	6/26/2018	1/1/2019	R/MF Dishwasher	Revised Measure Description to reflect language related to ENERGY STAR® equipment; Updated savings estimation methodology to align with ENERGY STAR® calculator; Added water heating fuel type adjustment factors; Updated Coincidence Factor; Added Baseline and Compliance Efficiency detail in accordance ENERGY STAR®; Added detail to Operating Hours section; Revised EUL source	Pg. 24
6-18-2	R	6/26/2018	1/1/2019	R/MF Hot Water and Steam Pipe Insulation	Added language to Measure Description to restrict measure material, pipe diameter and installation conditions; Updated variable values, references, labels and definitions for consistency with other measures; Added water heating fuel type adjustment factors; Updated Coincidence Factor; Revised Baseline and Compliance Efficiency requirements and UA/L values; Updated Operating Hours section; Revised EUL source/value	Pg. 53
6-18-3	R	6/26/2018	1/1/2019	R/MF Refrigerant Charge Correction & Tune-Up – Air Conditioner and Heat Pump	Changed Measure Name and Measure Description to include system tune-up requirement; Revised approach to include HP heating savings; Added provisions for estimate of savings for small and large equipment; Removed default efficiency values; Updated Coincidence Factor; Edited Baseline Efficiency section to clarify application of derating factors, tabulated values and included approach for multi-circuit systems; Added detail to Compliance Efficiency and Operating Hours sections; Revised EUL source	Pg. 121

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-4	R	6/26/2018	1/1/2019	R/MF Circulator Pump – with Electronically Commutated (EC) Motor for Hydronic Distribution	Restricted measure to retrofit only; Added load factor to methodology; Added provisions for estimating peak demand savings; Added provisions for cooling systems; Updated baseline and qualifying efficiency and operating hours assumptions; Updated Coincidence Factor; Added detail in Compliance Efficiency, Operating Hours, and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 129
6-18-5	R	6/26/2018	1/1/2019	R/MF Duct Sealing and Insulation	Restricted measure to existing buildings, ductwork in unconditioned spaces and code compliance or better for eligibility; Required pre and post-implementation duct blaster testing; Added terms to equation to account for portion of ductwork located in unconditioned spaces; Added provisions for estimate of savings for small and large equipment and electric furnaces; Added cooling/heating Thermal Regain Factor adjustments; Removed default efficiency values; Updated Coincidence Factor; Revised Compliance Efficiency section to reflect minimum code requirement; Revised EUL source	Pg. 132
6-18-6	R	6/26/2018	1/1/2019	R/MF Outdoor Temperature Setback Control for Hydronic Boiler	Revised Measure Name to “Setback Control” instead of “Reset Control”; Clarified restriction to retrofit of existing boilers only; Removed default boiler capacity section, requiring actual boiler input for calculation; Updated Baseline Efficiency and Compliance Efficiency sections; Revised EUL to reflect the remaining useful life of the existing boiler	Pg. 165

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-7	R	6/26/2018	1/1/2019	C/I Vending Machine and Novelty Cooler Control	Revised Measure Name to accommodate occupancy sensing controls and updated Measure Description to clarify application and restrictions; Updated approach for establishing operating hours; Added detail to Baseline Efficiency, Compliance Efficiency, Operating Hours and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 255
6-18-8	R	6/26/2018	1/1/2019	C/I Air Dryer - Refrigerated	Updated Measure Description to clarify application and restrict to single compressor systems; Revised assumed ΔkW/CFM value; Added peak operation Boolean; Revised EUL source	Pg. 284
6-18-9	R	6/26/2018	1/1/2019	C/I Faucet – Low Flow Aerator	Added restriction to Measure Description for public lavatories and applied general language updates; Revised presentation of methodology and variable terms and definitions to align with other measures; Added flow restriction adjustment factors; Updated usage/operating assumptions; Added detail to Baseline Efficiency, Qualifying Efficiency and Operating Hours sections; Included table of default days per year by facility type; Revised EUL source	Pg. 315
6-18-10	R	6/26/2018	1/1/2019	C/I Refrigerant Charge Correction & Tune-Up – CAC and ASHP	Changed Measure Name and Measure Description to include system tune-up requirement; Revised approach to include HP heating savings; Added provisions for estimate of savings for small and large equipment; Removed default efficiency values; Edited Baseline Efficiency section to clarify application of derating factors, tabulated values and included approach for multi-circuit systems; Added detail to Compliance Efficiency and Operating Hours sections; Revised EUL source	Pg. 333

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
6-18-11	R	6/26/2018	6/26/2018	C/I Demand Control Ventilation (DCV)	Added detail to the Measure Description regarding code compliance, restrictions to existing conditions and development of heating side savings; Added NYC ESF values; Updated Baseline Efficiency requirement	Pg. 406
6-18-12	R	6/26/2018	1/1/2019	C/I Motor Replacement	Revised Measure Description to include phase/size/speed restrictions and compliance requirements; Updated savings estimation approach to assume equivalent power rating pre and post; Added detail to Baseline and Compliance Efficiency sections; Added default operating hours by application and facility type to Operating Hours section; Added Ancillary Fossil Fuel/Electric Savings Impacts language; Revised EUL source	Pg. 441
6-18-13	R	6/26/2018	1/1/2019	C/I Blower Fan – with Electronically Commutated (EC) Motor for HVAC Distribution	Revised Measure Name and Measure Description to refer to Electronically Commutated Motors; Defined baseline condition as single-speed PSC motors; Updated variable terms and definitions for consistency with other measures; Removed default wattage table; Added detail to Baseline Efficiency, Compliance Efficiency, Operating Hours and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 347
6-18-14	R	6/26/2018	1/1/2019	C/I Freezer and Cooler Door Gaskets	Modified Measure Description to clarify application; Revised algorithms and variable terms and definitions for consistency with other measures; Updated assumed ΔkWh/ft values; Updated Coincidence Factor; Revised Baseline Efficiency section; Added detail to Operating Hours and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source	Pg. 468
6-18-15	A	6/26/2018	6/26/2018	R/MF Boiler Tune-Up	New Measure Added	Pg. 145
6-18-16	A	6/26/2018	6/26/2018	R/MF Steam Trap Repair or Replacement – Low Pressure Space Heating	New Measure Added	Pg. 172

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6-18-17	A	6/26/2018	6/26/2018	R/MF Pool Pumps	New Measure Added	Pg. 198
6-18-18	A	6/26/2018	6/26/2018	C/I Dishwasher	New Measure Added	Pg. 237
6-18-19	A	6/26/2018	6/26/2018	C/I Ice Maker	New Measure Added	Pg. 246
6-18-20	A	6/26/2018	6/26/2018	C/I Instantaneous Water Heater	New Measure Added	Pg. 308
6-18-21	R	6/26/2018	1/1/2019	Appendix P	Updated EUL entries for all measures contained in this Record of Revision.	Pg. 746
6-18-22	R	6/26/2018	1/1/2019	Glossary	Added entries to align with all measures contained in this Record of Revision.	Pg. 759
9-18-1	R	9/28/2018	1/1/2019	R/MF Dishwasher	Corrected coincidence factor in Summary of Variables and Data Sources section to align with coincidence factor in Coincidence Factor section	Pg. 24
9-18-2	R	9/28/2018	1/1/2019	R/MF Air Leakage Sealing	Restricted measure to retrofit only; Required pre and post-implementation blower door testing in single-family homes and multifamily buildings less than 50,000SF; Revised correction factor to height and zone correction factors; Removed HVAC system and distribution system efficiencies from blower door algorithm; Updated terms for consistency with other measures; Updated Coincidence Factor; Added detail to Baseline Efficiency section regarding requirement of blower door testing as applicable; Revised Compliance Efficiency section to reflect minimum code requirement	Pg. 48
9-18-3	R	9/28/2018	1/1/2019	R/MF Opaque Shell Insulation	Restricted measure to retrofit only; Removed HVAC system and distribution system efficiencies from algorithm; Updated terms for consistency with other measures; Updated Coincidence Factor; Defined baseline condition as building shell not compliant with code; Added detail to Compliance Efficiency section to reflect code compliance; Revised EUL source/value	Pg. 59

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9-18-4	R	9/28/2018	1/1/2019	R/MF Window and Through-the-Wall Air Conditioner Cover and Gap Sealer	Updated Measure Description to clarify application and restrictions; Added Annual Electric Energy Savings algorithm; Updated variable terms and definitions for consistency with other measures; Updated Heating Degree Days assumed value; Updated Heating Plant Seasonal Efficiency to heating system efficiencies and added default tables; Added detail to Baseline Efficiency, Compliance Efficiency, and Operating Hours sections	Pg. 62
9-18-5	R	9/28/2018	1/1/2019	R/MF Heat Pump – Air Source (ASHP)	Corrected heating component of Annual Electric Energy Savings equation	Pg. 153
9-18-6	R	9/28/2018	1/1/2019	R/MF Submetering	Changed Measure Name to “Submetering” instead of “Sub-metering”; Added language to the Measure Description regarding application and code compliance; Added algorithm to capture Peak Coincident Demand Savings; Updated Energy Savings Factor value and source; Added Coincidence Factor; Added detail to Baseline Efficiency, Compliance Efficiency, Operating Hours, and Ancillary Fossil Fuel Savings Impacts sections; Added EUL source/value	Pg. 170
9-18-7	R	9/28/2018	1/1/2019	R/MF Pool Pump	Updated Measure Description to reflect language updated ENERGY STAR® equipment and application; Revised algorithms, variable terms, definitions, and default values to replace Energy Factor with Weighted Energy Factor; Updated Coincidence Factor; Updated Baseline and Compliance Efficiency sections to reflect WEF	Pg. 198
9-18-8	R	9/28/2018	1/1/2019	C/I Engine Block Heater Timer	Modified Measure Description to clarify application; Updated variable terms and definitions for consistency with other measures; Included assumed values when information unavailable	Pg. 208

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9-18-9	R	9/28/2018	1/1/2019	C/I Refrigerators and Freezers	Revised Measure Name to "Refrigerators and Freezers" from "Refrigerator Replacement"; Revised Measure Description to reflect language related to ENERGY STAR® equipment; Removed Occupant and Market Factors; Updated Maximum Daily Energy Consumption of baseline equipment to reflect code requirements and compliance equipment to reflect ENERGY STAR® requirement; Updated Operating Hours and Ancillary Fossil Fuel Savings Impacts sections; Revised EUL source	Pg. 242
9-18-10	R	9/28/2018	1/1/2019	C/I Cool Roof	Added language to Measure Description to clarify code requirement and limitation of available models; Restricted measure to existing buildings constructed before and have not undergone roof improvements since 2012; Updated Baseline Efficiency, Compliance Efficiency and Operating Hours sections; Revised EUL source	Pg. 264
9-18-11	R	9/28/2018	1/1/2019	C/I Window – Film	Added language to Measure Description to clarify application; Restricted measure to existing buildings; Updated variable terms and definitions for consistency with other measures; Revised language in Baseline Efficiency, Compliance Efficiency, and Operating Hours sections; Revised EUL source	Pg. 274

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9-18-12	R	9/28/2018	1/1/2019	C/I Engineered Air Nozzle	Modified Measured Description to clarify application; Updated variable terms and definitions for consistency with other measures; Revised flow rate to equation based on diameter; Updated hours to capture nozzle usage, with prior default if necessary; Added peak operation Boolean; Removed Annual Gas Energy Savings algorithm; Added default air compressor efficiencies table; Revised Coincidence Factor for consistency with other measures; Added detail to Baseline Efficiency, Compliance Efficiency, and Operating Hours sections	Pg. 287
9-18-13	R	9/28/2018	1/1/2019	C/I No Air Loss Water Drain	Added detail to Measure Description; Revised algorithms and variable terms and definitions for consistency with other measures; Added peak operation Boolean; Added default air compressor efficiencies table; Added detail to Baseline Efficiency, Compliance Efficiency, and Operating Hours sections; Revised EUL source/value	Pg. 290
9-18-14	R	9/28/2018	1/1/2019	C/I Duct Sealing and Insulation	Restricted measure to existing buildings, ductwork located outside the thermal envelope, and code compliance or better for eligibility; Required visual inspection and pre and post-implementation outdoor duct leakage testing; Added provisions for estimation of savings for small and large equipment and electric furnaces; Added cooling/heating Thermal Regain Factor adjustments; Removed default efficiency values; Revised Compliance Efficiency section to reflect minimum code requirement; Revised EUL source	Pg. 362

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9-18-15	R	9/28/2018	1/1/2019	C/I Bi-Level Lighting	Modified Measure Description to clarify application and compliance with code; Restricted measure to retrofit or replacement in existing buildings; Revised algorithm to reflect savings based on Energy and Demand Savings Factors; Updated variable terms and definitions for consistency with other measures; Updated hours; Added ESF calculation, variable terms and definitions and default values; Added Coincidence Factor specific to parking lots; Updated baseline condition to interior spaces with year-round illumination requirements and parking lots; Added detail to Baseline Efficiency, Compliance Efficiency, Operating Hours, and Ancillary Fossil Fuel/Electric Savings Impacts sections; Revised EUL source/value	Pg. 436
9-18-16	R	9/28/2018	1/1/2019	C/I Evaporator Fan Motor – with Electronically Commutated (EC) Motor for Refrigerated Case or Walk-In Cooler	Added “Evaporator” to Measure Title; Restricted measure to a 1:1 motor output replacement and in systems not required by code; Revised algorithm of refrigerated cases and variable terms and definitions for consistency with coolers/freezers; Added detail to Baseline Efficiency and Compliance Efficiency sections to reflect code requirements	Pg. 456
9-18-17	A	9/28/2018	9/28/2018	R/MF Combination (“Combi”)-Boilers Furnaces	New Measure Added	Pg. 147
9-18-18	A	9/28/2018	9/28/2018	C/I Steam Trap Repair or Replacement – Other Applications	New Measure Added	Pg. 449
9-18-19	R	9/28/2018	9/28/2018	Appendix E	Revised all instances of “roof” to “ceiling”	Pg. 562

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9-18-20	R	9/28/2018	1/1/2019	Appendix P	Updated EUL entries for all measures contained in this Record of Revision; Updated EUL source and value for R/MF Storage Water Heater – Gas; Added detail to EUL source for R/MF Air Conditioner and Heat Pump – Right-Sizing; Corrected EUL source URL for R/MF Heat Pump – Ground Source; Revised EUL year cap to 15 per DEER 2014 for R/MF Light Fixture – Linear Fluorescent	Pg. 746
9-18-21	R	9/28/2018	1/1/2019	Glossary	Added entries to align with all measures contained in this Record of Revision	Pg. 759
12-18-1	R	12/28/2018	12/28/2018	R/MF Clothes Dryer	Removed extraneous multiplication symbol from Annual Gas Energy Savings equation	Pg. 13
12-18-2	R	12/28/2018	12/28/2018	R/MF Air Leakage Sealing	Updated Measure Description to clarify inspection requirements and application of available equations; Updated terms for consistency with other measures	Pg. 48
12-18-3	R	12/28/2018	12/28/2018	R/MF Heat Pump Water Heater (HPWH) - Air Source	Corrected conversion factor unit in Annual Gas Energy Savings equation; Updated Compliance Efficiency section to require ENERGY STAR® compliant equipment to qualify	Pg. 71
12-18-4	R	12/28/2018	12/28/2018	C/I Clothes Dryer	Removed extraneous multiplication symbol from Annual Gas Energy Savings equation	Pg. 211
12-18-5	R	12/28/2018	12/28/2018	C/I Unitary Air Conditioner and Unitary & Applied Heat Pump	Updated Measure Description to include multifamily buildings; Baseline Efficiencies section updated to clarify conditions where federal energy conservation standards are more stringent and should be applied over NYS and NYC codes	Pg. 338
12-18-6	A	12/28/2018	12/28/2018	R/MF Soundbar	New Measure Added	Pg. 33
12-18-7	A	12/28/2018	12/28/2018	R/MF Drain Water Heat Recovery	New Measure Added	Pg. 107
12-18-8	A	12/28/2018	12/28/2018	R/MF Gas Pool Heaters	New Measure Added	Pg. 204
12-18-9	A	12/28/2018	12/28/2018	C/I Hot Water and Steam Pipe Insulation	New Measure Added	Pg. 267
12-18-10	A	12/28/2018	12/28/2018	C/I Low-Flow Salon Valves	New Measure Added	Pg. 320
12-18-11	A	12/28/2018	12/28/2018	C/I Infrared Heaters	New Measure Added	Pg. 386

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12-18-12	A	12/28/2018	12/28/2018	C/I Water Source Heat Pumps	New Measure Added	Pg. 380
12-18-13	A	12/28/2018	12/28/2018	C/I Variable Refrigerant Flow Systems	New Measure Added	Pg. 389
12-18-14	A	12/28/2018	12/28/2018	C/I Guest Room Energy Management System	New Measure Added	Pg. 416
12-18-15	A	12/28/2018	12/28/2018	C/I Outdoor Temperature Setback Control for Hydronic Boiler	New Measure Added	Pg. 410
12-18-16	A	12/28/2018	12/28/2018	C/I Thermostatic Radiator Valves	New Measure Added	Pg. 402
12-18-17	R	12/28/2018	12/28/2018	Appendix P	Updated EUL entries for all measures contained in this Record of Revision.	Pg. 746
12-18-18	R	12/28/2018	12/28/2018	Glossary	Added entries to align with all measures contained in this Record of Revision.	Pg. 759
1-19-1	R	1/31/2019	1/31/2019	R/MF Air Conditioner and Heat Pump – Right Sizing	No revisions applied – measure removed from TRM.	N/A
1-19-2	R	1/31/2019	1/31/2019	C/I Thermostat – Programmable Setback (Non-Communicating)	No revisions applied – measure removed from TRM.	N/A
1-19-3	R	1/31/2019	1/31/2019	R/MF Blower Fan – with Electronically Commutated (EC) Motor for HVAC Distribution	Updated measure title from Blower Fan – with Electronically Commutated Motor for Furnace Distribution. Added language restricting estimation of demand savings to projects with central AC.	Pg. 126
1-19-4	R	1/31/2019	1/31/2019	R/MF Thermostat – Learning	Updated measure title from Learning Thermostat for consistency with other thermostat measures.	Pg. 173
1-19-5	R	1/31/2019	1/31/2019	R/MF Thermostat – Wi-Fi (Communicating)	Removed restriction on application in Demand Response programs.	Pg. 183
1-19-6	R	1/31/2019	1/31/2019	R/MF Thermostatic Radiator Valve – One Pipe Steam Radiator	A table of HDD by city was added for a more accurate capture of heating degree days by location.	Pg. 185
1-19-7	R	1/31/2019	1/31/2019	C/I Refrigerant Charge Correction & Tune Up – CAC and ASHP	Updated conversion factor and added definition	Pg. 333

Revision Number	Addition/ Revision	Issue Date	Effective Date	Measure	Description of Change	Location/Page in TRM
1-19-8	R	1/31/2019	1/31/2019	Multiple Sections	Updates applied to ensure consistent use of terms, units, symbols, fonts, number formats, table formats, number of significant figures for like terms and constant, default and variable values. Updates applied to align standard language, abbreviation and acronym use and formatting throughout TRM. Updates applied to establish consistency in formula structure and table content, align indents, and justify text and data within data tables and bulleted lists. Broken links in footnotes, References sections and elsewhere restored. Versions, dates and links added to reference of other TRMs. Updated language in Coincidence Factor section of all measures to indicate that the value provided is "prescribed" rather than "recommended" or "suggested".	Throughout

Note: Revisions and additions to the measures listed above were undertaken by the Joint Utilities Technical Resource Manual (TRM) Management Committee between April 17, 2018 – January 25, 2019.

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INTRODUCTION

The Commission is committed to using the best possible information in the estimation of savings from measures installed through ratepayer funded energy efficiency programs. Information contained within this manual supersedes information contained in earlier versions and is effective as of the date specified.

HISTORY

In a series of Commission orders related to approving the portfolio of programs associated with the Energy Efficiency Portfolio Standard (EEPS), the Commission approved technical manuals designed to provide a standardized, fair, and transparent approach for measuring program energy savings. The five technical manuals approved between December 2008 and December 2009 covered a variety of measures applicable to the single-family, multi-family, and commercial/industrial sectors. They were consolidated into one manual entitled, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs-Residential, Multi-family, and Commercial/Industrial Measures* (“the Consolidated Technical Resource Manual”) dated October 15, 2010[2] with an effective date of January 1, 2011.

On December 10, 2014, the Department of Public Service Staff (Staff), released the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 2* (Version 2) incorporating all revisions between October 15, 2011 and September 30, 2014, with an effective date of December 10, 2014.

The release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 3* (Version 3) incorporated all revisions between December 10, 2014 and June 1, 2015, with an effective date of January 1, 2016.

The release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 4* (Version 4) incorporated all revisions between December 10, 2014 and June 1, 2015, with an effective date of January 1, 2017.

The release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 5* (Version 5) incorporates all revisions between April 29, 2016 and June 30, 2017, with an effective date of January 1, 2018.

The release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 5.1* (Version 5.1) incorporated all revisions between July 1, 2017 and December 31, 2017

[2] For purposes of tracking Technical Resource Manual updates, the October 15, 2010 Consolidated Technical Resource Manual will also be referred to as Version 1, with the protocol of all subsequent Consolidated Updates being released with sequential Version numbers.

with an effective date of January 1, 2018. Version 5.1 was filed for administrative purposes so that information effective January 1, 2018 is published in one location.

The release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 5.2* (Version 5.2) incorporated all revisions between July 1, 2017 and December 31, 2017 with an effective date of January 1, 2018. Version 5.2 was filed for administrative purposes so that information effective January 1, 2018 was published in one location. Version 5.2 includes omissions found in the compiling of Q3-2017 Records-of Revision into Version 5.1.

The release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 6* (Version 6) incorporated all revisions between July 1, 2017 and March 29, 2018, with an effective date of January 1, 2019, new measures between December 31, 2017 and March 29, 2018 with an effective date of March 29, 2018 as well as the removal of one measure effective March 30, 2018.

This current release of the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential, and Commercial/Industrial Measures, Version 6.1* (Version 6.1) incorporates all revisions between April 17, 2018 and January 25, 2019, with an effective date of January 31, 2019. Version 6.1 was filed for administrative purposes so that information effective January 1, 2019 was published in one location. Version 6.1 also includes revisions applied to establish consistent language, content and formatting throughout the TRM.

For a reference of historical changes to measures presented in the Technical Resource Manual (TRM), each measure chapter includes a section titled "Record of Revision." If the measure was not revised between its original publication (in 2008-2009) and its publication in the Consolidated Technical Resource Manual, the Revision Number is 0. If the measure was added/revised between its original publication (in 2008-2009) and its publication in the Consolidated Technical Manual, the Revision Number will correspond to the number of changes/additions of that measure (ex. 1 or 2). Since the publication of the Consolidated Technical Resource Manual, dated October 15, 2010, Staff has worked with the E^2 Working Group[3] and its Technical Resource Manual/Measure Classification Lists Subcommittee to review and approve proposed revisions utilizing the process established by Commission Order[4]. These revisions have been documented through the issuance of Record of Revisions and the Revision Number will correspond to the Revision Number assigned on its date of issue. These Revision Numbers identifies the month and year of the Record of Revision in which the measure appeared and includes an index number, which indicates the order in which that measure appeared in the identified Record of Revision (e.g. Revision Number "1-17-5" refers to the fifth measure appearing in the Record of Revision published in January 2017).

[3] The E^2 Working Group was formed on February 28, 2014 per the December 26, 2013 Commission Order in Case 07-M-0548 which directed the merger of the functions of the former Implementation Advisory Group (IAG) and the Evaluation Advisory Group (EAG) and directed Staff to work with NYSERDA and the utilities to form an E^2 Working Group.

[4] Case 07-M-0548, Order Approving Modifications to the Energy Efficiency Portfolio Standard (EEPS) Program to Streamline and Increase Flexibility in Administration (issued June 20, 2011).

Revisions made subsequent to the release of Version 6 have been compiled for ease of reference in the "Table of Revisions/Changes" located just before the Table of Contents in this manual. These revisions are issued concurrent with Version 6.

SYSTEM PEAK DEMAND DEFINITION

System peak demand typically refers to the highest amount of electricity being consumed at any one point in time across the entire system network. In most cases, the system network referred to is the New York Control Area, managed by the New York Independent System Operator. It is the maximum level of hourly demand during a specific period. The peak periods most commonly identified are annual and seasonal (summer and winter). [5] Peak coincident demand is the demand of a measure that occurs at the same time as the system peak.

The TRM equations are developed to estimate peak electricity savings (kW) along with electricity consumption and gas consumption savings. The definition of the peak demand period for conducting engineering simulations and estimating coincidence factors are as follows:

Electricity

According to the NYISO, system peaks generally occur during the hour ending at 5 pm on the hottest non-holiday weekday. The peak day can occur in June, July, or August, depending on the weather. Program Administrators (PAs) should calculate coincident peak demand savings based on the hottest summer non-holiday weekday during the hour ending at 5pm.

Building energy simulation programs or other calculation techniques using the Typical Meteorological Year version 3 (TMY3) data from the National Renewable Energy Laboratory (NREL) shall use the calendar year definition and day of the year as shown below:

City	Date	Temperature	Calendar Year
Albany	July 21	96	1995
Binghamton	August 14	93	1998
Buffalo	July 21	89	1995
Massena	August 15	94	1997
NYC	July 13	98	1990
Poughkeepsie	June 10	92	2005
Syracuse	July 4	97	2003

Note: For peak demand simulations, the calendar year is defined so that the days above fall on a non-holiday Friday. For Syracuse, this requires redefining the July 4th holiday.

Building energy simulation programs or other calculation techniques using different weather data sets shall choose a coincident peak demand hour consistent with the NY ISO definition above.

[5] Glossary of Terms, Version 2.1, Northeast Energy Efficiency Partnerships, A project of the Regional Evaluation, Measurement and Verification Forum, Prepared by Paul Horowitz PAH Associates, p.25.

Natural Gas

The peak gas definition is based on the program-induced change in the average daily gas flow in which the distribution system, on average, reaches its pumping/consumption capacity such that as the temperature falls lower (or the heating degree days go higher) gas consumption does not increase. Setting the peak gas definition for this condition means that the gas peak is calculated to reflect the decreased cubic feet of natural gas expected to not flow through the distribution system during the 24-hour period as a result of the impacts of the gas energy efficiency program.

NATURAL GAS PEAK SAVINGS DEFINITION

Up State: The number of therms saved during a day, a 24 hour period starting at 10:00AM, in which the average temperature is minus nine -9^{o}F (-22.8 ^{o}C).

Down State: The number of therms saved during a day, a 24 hour period starting at 10:00AM, in which the average temperature is zero^{o}F (-17.8^{o}C).

COINCIDENCE FACTOR

For purposes used in this manual, the Coincidence Factor (CF) is expressed as a ratio with the numerator being the simultaneous demand of a similar group of electrical appliances (measures) within a specified period, to the sum of their individual maximum demands within the same period.

ANCILLARY NON-GAS FOSSIL FUEL IMPACTS

The measures in this Manual that provide non-gas fuel interactions shall use the therm impact equations, with the following conversion factors:

Fuel	Heating value	Conversion Factor
Propane	71,000 BTU/gal	1.41 gal per therm
#2 Fuel Oil	115,000 BTU/gal	0.87 gal per therm
#6 Fuel Oil	124,000 BTU/gal	0.81 gal per therm

ANNUAL/LIFE-CYCLE SAVINGS

The energy savings methodologies presented in this Manual are designed to provide first year annual gross energy savings. Life cycle energy savings are calculated by multiplying first year gross energy savings by the EUL.

NET TO GROSS ADJUSTMENTS

The savings approaches presented in this Manual provide gross energy saving estimates and specify the approaches for obtaining those estimates. The New York Department of Public Service policy specifies that savings projections used for predicting energy savings will be net savings. To arrive at net savings the gross estimates presented in this Manual must be adjusted to account for free riders and spillover.

Free rider adjustments erode the gross savings estimate by subtracting out the savings that would have occurred without the program's incentive or influence. Spillover adjustments increase savings by counting the additional savings that occur as a result of two possible conditions. First, participants can replicate that same action (participant spillover) outside of the program participation process, providing additional savings. Second, the program can influence the way non-participants make energy saving decisions that result in additional savings not associated with a specific participation event. Together, the subtraction of savings for free riders, plus the addition of savings for spillover tend to offset each other to a significant degree. As a result, for the purposes of estimating program impacts, the savings estimates presented in this Manual, or the savings produced using the calculation approaches described in this Manual, must be multiplied by 0.90 to arrive at an estimated net energy savings for each measure.

As program evaluations are completed, this factor will be adjusted up or down as appropriate by program, for each measure included in this Manual. Over time, the adjustment factor will evolve to be more accurate and will be focused on specific types of programs and delivery approaches. To continue to standardize the net impact estimation approach at this time, a net to gross conversion factor of 0.90 will continue to be applied to the gross saving estimates.

EQUIVALENT FULL LOAD HOURS (EFLH), FOR HEATING OR COOLING

The equivalent hours that a measure would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).[6] The ratio of the annual building energy (cooling or heating) consumed to the peak energy required is used to calculate EFLH. The listing of heating and cooling Equivalent Full Load Hours for seven cities in New York State can be found in Appendix G. Accordingly, the ratio for EFLH cooling is shown below:

$$EFLH_{cooling} = \left(\frac{\text{Annual kWh}_{cooling}}{kW_{peak,\ cooling}} \right)$$

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[6] Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2013-2015 Program Years – Plan Version, October 2012

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

APPLIANCE

CLOTHES WASHER

Measure Description

This measure covers residential grade clothes washers meeting the criteria established under the ENERGY STAR® Program, Version 8.0, effective February 5, 2018, installed in residential settings.[7] ENERGY STAR® clothes washers have a higher Integrated Modified Energy Factor (IMEF) 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 45% less water than comparable non-qualified models.[8]

This measure addresses installation of top and front-loading residential clothes washers with capacities greater than 1.6 ft^3 and less than 8.0 ft^3. This measure applies to residential equipment installed in single-family homes or in multifamily buildings within the residential unit; it is not intended for use with washers in multifamily common areas.

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings[9]

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\Delta kWh_{washer} + (\Delta kWh_{wh} \times ElecSF_{wh}) + (\Delta kWh_{dryer} \times ElecSF_{dryer})\right]$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \left[(\Delta therms_{wh} \times GasSF_{wh}) + (\Delta therms_{dryer} \times GasSF_{dryer})\right]$$

[7] ENERGY STAR® Program Requirements Product Specification for Clothes Washers, Eligibility Criteria Version 8.0, February 2018
[8] Efficiency of ENERGY STAR® products: https://www.energystar.gov/products/appliances/clothes_washers
[9] Savings calculator for ENERGY STAR® Qualified Appliances (accessed 2/8/2018)

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
$\Delta therms$	= Annual gas energy savings
units	= Number of measures installed under the program
ΔkWh_{washer}	= Annual clothes washer electric energy savings
ΔkWh_{wh}	= Annual electric water heating energy savings
ΔkWh_{dryer}	= Annual electric dryer energy savings
$ElecSF_{wh}$	= Electric Savings Factor for water heaters
$ElecSF_{dryer}$	= Electric Savings Factor for dryers
$\Delta therms_{wh}$	= Annual gas water heating energy savings
$\Delta therms_{dryer}$	= Annual gas dryer energy savings
$GasSF_{wh}$	= Gas Savings Factor for water heaters
$GasSF_{dryer}$	= Gas Savings Factor for dryers
hrs	= Annual run hours of clothes washer
CF	= Coincidence Factor

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh_{washer}		Lookup from Per Unit Savings table below, based on product class.
ΔkWh_{wh}		Lookup from Per Unit Savings table below, based on product class.
ΔkWh_{dryer}		Lookup from Per Unit Savings table below, based on product class.
$ElecSF_{wh}$	Electric WH: 1.0 Gas WH: 0 Unknown: 0.34	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[10]
$ElecSF_{dryer}$	Electric Dryer: 1.0 Gas Dryer: 0 Unknown: 0.67	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[11]
$\Delta therms_{wh}$		Lookup from Per Unit Savings table below, based on product class.
$\Delta therms_{dryer}$		Lookup from Per Unit Savings table below, based on product class.

[10] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC1.7 ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with electric or gas water heating)

[11] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC3.7 ("Unknown" calculated as the number of homes with electric dryers divided by the total number of homes with electric or gas dryers)

Variable	Value	Notes
$GasSF_{wh}$	Electric WH: 0 Gas WH: 1.0 Unknown: 0.66	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[12]
$GasSF_{dryer}$	Electric Dryer: 0 Gas Dryer: 1.0 Unknown: 0.33	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[13]
hrs	295	
CF	0.029	

Integrated Modified Energy Factor, IMEF[14] (ft^3/kWh/cycle), is the energy performance metric for ENERGY STAR® certified residential clothes washers as of March 7, 2015.

IMEF is a measure of energy efficiency that considers the energy used by the washer during the cycle and while on standby, the energy used to heat the water, and the energy used to run the dryer. IMEF is the quotient of the cubic foot (or liter) capacity of the clothes container divided by the sum of the machine electrical energy consumption, the hot water energy consumption, the energy required for removal of the remaining moisture in the wash load, and the combined low-power mode energy consumption. A higher IMEF value reflects a more efficient clothes washer.[15]

Integrated Water Factor, IWF[16] is the water performance metric for residential clothes washers that allows the comparison of clothes washer water consumption independent of clothes washer capacity. Manufacturers must submit their water consumption factors with their ENERGY STAR® certified residential clothes washers. IWF 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[17].

Per Unit Savings[18,19,20,21]

Product Class	Clothes Washer (ΔkWh_{washer})	Elec. DHW (ΔkWh_{wh})	Gas DHW ($\Delta therm_{wh}$)	Elec. Dryer (ΔkWh_{dryer})	Gas Dryer ($\Delta therm_{dryer}$)
ENERGY STAR® Front Load Washer ≤ 2.5 ft^3	4	15	0.7	19	0.7
ENERGY STAR® Front Load Washer > 2.5 ft^3	6	35	1.6	169	6.5
ENERGY STAR® Top Load Washer ≤ 2.5 ft^3	4	17	0.8	75	2.9

[12] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC1.7 ("Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with electric or gas water heating)
[13] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC3.7 ("Unknown" calculated as the number of homes with gas dryers divided by the total number of homes with electric or gas dryers)
[14] 10 CFR 430 Subpart B, Appendix J2
[15] ENERGY STAR® Program Requirements Product Specification for Clothes Washers, Eligibility Criteria Version 8.0 February 2018
[16] 10 CFR 430 Subpart B, Appendix J2
[17] ENERGY STAR® Program Requirements Product Specification for Clothes Washers, Eligibility Criteria Version 8.0, February 2018
[18] Savings Calculator for ENERGY STAR® Qualified Appliances (accessed 2/8/2017)
[19] ENERGY STAR® Clothes Washers Key Product Criteria
[20] ENERGY STAR® Most Efficient 2018, Recognition Criteria Clothes Washers
[21] CEE Super Efficient Home Appliances Initiative, Residential Clothes Washer Specifications

Product Class	Clothes Washer (ΔkWh_{washer})	Elec. DHW (ΔkWh_{wh})	Gas DHW ($\Delta therm_{wh}$)	Elec. Dryer (ΔkWh_{dryer})	Gas Dryer ($\Delta therm_{dryer}$)
ENERGY STAR® Top Load Washer > 2.5 ft^3	12	46	2.1	144	5.5
ENERGY STAR® Most Efficient Front Load Washer ≤ 2.5 ft^3	6	22	1.0	28	1.1
ENERGY STAR® Most Efficient Front Load Washer > 2.5 ft^3	10	39	1.8	188	7.2
ENERGY STAR® Most Efficient Top Load Washer ≤ 2.5 ft^3	5	20	0.9	88	3.4
ENERGY STAR® Most Efficient Top Load Washer > 2.5 ft^3	22	90	4.1	279	10.7
CEE Tier 1 Front Load Washer ≤ 2.5 ft^3	4	15	0.7	19	0.7
CEE Tier 1 Front Load Washer > 2.5 ft^3	9	35	1.6	169	6.5
CEE Tier 1 Top Load Washer ≤ 2.5 ft^3	4	17	0.8	75	2.9
CEE Tier 1 Top Load Washer > 2.5 ft^3	21	84	3.8	260	9.9
CEE Tier 2 Front Load Washer ≤ 2.5 ft^3	6	22	1.0	28	1.1
CEE Tier 2 Front Load Washer > 2.5 ft^3	10	39	1.8	188	7.2
CEE Tier 2 Top Load Washer ≤ 2.5 ft^3	5	20	0.9	88	3.4
CEE Tier 2 Top Load Washer > 2.5 ft^3	20	80	3.6	248	9.5
CEE Advanced Tier Front Load Washer > 2.5 ft^3	11	43	2.0	206	7.9
CEE Advanced Tier Top Load Washer > 2.5 ft^3	21	85	3.9	264	10.1

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.029.[22]

Baseline Efficiencies from which Savings are Calculated

Clothes washers manufactured and distributed in commerce, as defined by 42 U.S.C. 6291(16), after January 1, 2018, must meet the energy conservation standards shown in the table below, as specified in the Code of Federal Regulations.[23]

Product Class	IMEF	IWF
Top-loading, Compact (< 1.6 ft^3)	≥ 1.15	≤ 12.0
Top-loading, Standard (≥ 1.6 ft^3)	≥ 1.57	≤ 6.5
Front-loading, Compact (< 1.6 ft^3)	≥ 1.13	≤ 8.3
Front-loading, Standard (≥ 1.6 ft^3)	≥ 1.84	≤ 4.7

Compliance Efficiency from which Incentives are Calculated

For ENERGY STAR® qualified eligibility, clothes washers must be front or top-loading with capacities greater than 1.6 ft^3 and less than 8.0 ft^3 and not designated as Combination All-In One Washer-Dryers or Residential Clothes Washers with Heating Drying Functionality.[24] Additional qualifying product criteria are provided in the table below in order to capture anticipated savings

[22] Based on metered data from Navigant Consulting, "EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (6/1/2012 – 5/31/2013) Appliance Rebate Program." March 2014, page 36. This report is not publicly available, but is referenced by the Mid-Atlantic Technical Reference Manual, Version 7.0, May 2017.
[23] 10 CFR 430.32(g)(4)
[24] ENERGY STAR® Program Requirements Product Specification for Clothes Washers

associated with higher efficiency models. The highest efficiency "Product Class" that the qualifying unit is eligible for should be used to establish savings from the Per Unit Savings table above.

ENERGY STAR® [25] and Consortium for Energy Efficiency (CEE)[26] Product Criteria Levels are shown in the table below:

Product Class	IMEF	IWF
ENERGY STAR® Clothes Washer ≤ 2.5 ft^3	≥ 2.07	≤ 4.2
ENERGY STAR® Front Load Washer > 2.5 ft^3	≥ 2.76	≤ 3.2
ENERGY STAR® Top Load Washer > 2.5 ft^3	≥ 2.06	≤ 4.3
ENERGY STAR® Most Efficient Washer ≤ 2.5 ft^3	≥ 2.20	≤ 3.7
ENERGY STAR® Most Efficient Washer > 2.5 ft^3	≥ 2.92	≤ 3.2
CEE Tier 1 Clothes Washer ≤ 2.5 ft^3	≥ 2.07	≤ 4.2
CEE Tier 1 Clothes Washer > 2.5 ft^3	≥ 2.76	≤ 3.2
CEE Tier 2 Clothes Washer ≤ 2.5 ft^3	≥ 2.20	≤ 3.7
CEE Tier 2 Clothes Washer > 2.5 ft^3	≥ 2.92	≤ 3.2
CEE Advanced Tier Clothes Washer > 2.5 ft^3	≥ 3.10	≤ 3.0

Operating Hours

An average of 295 annual one-hour active wash cycles is assumed in order to estimate conventional and qualifying unit consumption and demand savings.[27]

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.

[25] ENERGY STAR® Most Efficient 2018, Recognition Criteria Clothes Washers
[26] CEE Super Efficient Home Appliances Initiative, Residential Clothes Washer Specifications
[27] 10 CFR 430 Subpart B, Appendix J2

References

1. ENERGY STAR® Program Requirements Product Specification for Clothes Washers, Eligibility Criteria Version 8.0, February 2018
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%208.0%20Clothes%20Washer%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf
2. ENERGY STAR® Certified Products, Appliances, Clothes Washers
   Available from: https://www.energystar.gov/products/appliances/clothes_washers/
3. Savings calculator for ENERGY STAR® Qualified Appliances
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
4. EIA Residential Energy Consumption Survey (RECS) 2015 Survey Data for Middle Atlantic States.
   Available from:
   https://www.eia.gov/consumption/residential/data/2015/hc/php/hc1.7.php
5. 10 CFR 430 Subpart B, Appendix J2 - Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-automatic Clothes Washers
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.j2
6. ENERGY STAR® Clothes Washers Key Product Criteria
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   Available from:
   http://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V7_FINAL.pdf
10. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
    Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
1-17-1	12/31/2016
3-18-6	3/29/2018

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CLOTHES DRYER

Measure Description

This measure covers residential grade clothes dryers meeting the criteria established under the ENERGY STAR® Program, Version 1.1, effective May 5, 2017 installed in residential settings.[28] ENERGY STAR® clothes dryers have a higher combined energy factor (CEF), and save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions, improving air circulation, and improved efficiency of motors. Reduced dryer runtime is achieved through automatic termination of the dryer cycles based on temperature and moisture sensors. Clothes dryers originally qualified for the ENERGY STAR® label in May 2014. Clothes dryers that have earned this label are approximately 20% more efficient than non-qualified models.[29]

This measure applies to clothes dryers installed in single family homes and in-unit multifamily equipment. For residential grade clothes dryers installed in multifamily common areas, the Clothes Dryer measure prescribed in the Commercial and Industrial section of this manual should be used.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times Cycles_{annual} \times Load \times \left(\frac{F_{elec,baseline}}{CEF_{baseline}} - \frac{F_{elec,ee}}{CEF_{ee}}\right)$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times Cycles_{annual} \times Load \times \left(\frac{F_{gas,baseline}}{CEF_{baseline}} - \frac{F_{gas,ee}}{CEF_{ee}}\right) \times \frac{3{,}412}{100{,}000}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$Cycles_{annual}$	= Number of dryer cycles per year
Load	= Average total weight (lbs) of clothes per drying cycle
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure

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[28] ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017

[29] Efficiency of ENERGY STAR® products: https://www.energystar.gov/products/appliances/clothes_dryers

F_{elec} = Percentage of energy consumed that is derived from electricity
F_{gas} = Percentage of energy consumed that is derived from gas
CEF = Combined energy factor (lb/kWh)
hrs = Annual run hours of clothes dryer
CF = Coincidence Factor
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$Cycles_{annual}$		Lookup based on efficient dryer type in table below.[30]
Load		Lookup based on efficient dryer type in table below.[31]
$F_{elec,baseline}$		Lookup based on efficient dryer type in table below.[32]
$F_{elec,ee}$		Lookup based on efficient dryer type in table below.[33]
$F_{gas,baseline}$		Lookup based on efficient dryer type in table below.[34]
$F_{gas,ee}$		Lookup based on efficient dryer type in table below.[35]
$CEF_{baseline}$		Lookup based on efficient dryer type in table below.[36]
CEF_{ee}		Lookup based on efficient dryer type in table below.[37]
hrs		Lookup based on efficient dryer type in table below.[38]
CF	0.042	

Key Variables Lookup Table

Variable	Dryer Type				
	Vented Gas Dryer	*Ventless or Vented Electric, Standard ≥ 4.4 ft³*	*Ventless or Vented Electric, Compact (120V) < 4.4 ft³*	*Vented Electric, Compact (240V) < 4.4 ft³*	*Ventless Electric, Compact (240V) < 4.4 ft³*
$Cycles_{annual}$	283	283	283	283	283
Load	8.45	8.45	3.00	3.00	3.00
$F_{elec,baseline}$	0.05	1.00	1.00	1.00	1.00
$F_{elec,ee}$	0.05	1.00	1.00	1.00	1.00
$F_{gas,baseline}$	0.95	0.00	0.00	0.00	0.00
$F_{gas,ee}$	0.95	0.00	0.00	0.00	0.00

[30] Savings calculator for ENERGY STAR® Qualified Appliances (accessed 10/18/2017)
[31] Ibid.
[32] ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017
[33] Ibid.
[34] Ibid.
[35] Ibid.
[36] 10 CFR 430.32 (h)(3)
[37] ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017
[38] Savings calculator for ENERGY STAR® Qualified Appliances (accessed 10/18/2017)

Variable	Dryer Type				
	Vented Gas Dryer	*Ventless or Vented Electric, Standard ≥ 4.4 ft³*	*Ventless or Vented Electric, Compact (120V) < 4.4 ft³*	*Vented Electric, Compact (240V) < 4.4 ft³*	*Ventless Electric, Compact (240V) < 4.4 ft³*
$CEF_{baseline}$	3.30	3.73	3.61	3.27	2.55
CEF_{ee}	3.48	3.93	3.80	3.45	2.68
hrs	290	290	290	290	290

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.042.[39]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard efficiency, residential grade clothes dryer with operating specifications as defined in the Key Variables Lookup Table above.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential grade clothes dryer appearing on the ENERGY STAR® qualified products list.

Operating Hours

Operating hours for residential clothes dryers are provided in the Key Variables Lookup Table above.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

A clothes dryer releases heat to the surrounding environment. Conventional vented dryers also vent air outside the building. The associated HVAC impact of dryers depends upon a number of variables including climate and placement of a dryer (i.e., in a conditioned or unconditioned space). It is an area of ongoing research.[40] These impacts are excluded from the methodology prescribed herein until they can be quantified and substantiated through independent research.

[39] Based on Central Maine Power Company "Residential End-Use Metering Project", 1988. Using 8,760 data for electric clothes dryers, calculating the CF according to the PJM peak definition. This study is not publicly available, but is referenced by the Pennsylvania Technical Reference Manual, State of Pennsylvania, 2016. http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

[40] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryers, November 2011

Ancillary Electric Savings Impacts

See Ancillary Fossil Fuel Savings Impacts section above.

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   https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
3. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
4. Pennsylvania Technical Reference Manual, State of Pennsylvania, 2016.
   Available from:
   http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

Record of Revision

Record of Revision Number	Issue Date
6-16-1	6/30/2016
12-17-1	12/31/2017
12-18-1	12/28/2018

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DEHUMIDIFIER

Measure Description

This measure covers the installation of residential stand-alone or whole-house dehumidifiers meeting the minimum qualifying efficiency standards established under the ENERGY STAR® Program, Version 4.0, effective October 25, 2016.[41] With a higher Energy Factor than comparable non-qualified models, ENERGY STAR® dehumidifiers have more efficient refrigeration coils, compressors, and fans that use less energy to remove moisture in residential buildings. Dehumidifiers originally qualified for the ENERGY STAR® label in January 2001. Dehumidifiers that have earned this label are approximately 15% more efficient than non-qualified models. This measure is restricted to dehumidifiers with a product moisture removal capacity of less than or equal to 185 pints/day.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{pints/day \times 0.473 \times hrs}{24} \times \left(\frac{1}{EF_{baseline}} - \frac{1}{EF_{ee}}\right)$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
pints/day	= Product capacity to remove moisture (pints/day)
hrs	= Annual run hours of dehumidifier
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
EF	= Energy Factor (prior to June 13, 2019) or Integrated Energy Factor (on or after June 13, 2019)
CF	= Coincidence factor
0.473	= Conversion factor (liters/pint)
24	= Hours in one day

[41] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 4.0, February 2016

Summary of Variables and Data Sources

Variable	Value	Notes
pints/day		From application.
$EF_{baseline}$		Look up based on type and product capacity (pints/day) or case volume from Baseline Efficiencies section below. Note that the same rating metric (Energy Factor or Integrated Energy Factor) must be used for the baseline and energy efficient case to estimate savings.
EF_{ee}		From application, or look up based on product capacity (pints/day) in Compliance Efficiency section below. Note that the same rating metric (Energy Factor or Integrated Energy Factor) must be used for the baseline and energy efficient case to estimate savings.
hrs	1,632	Assumes 68 days of 24-hour operation.[42]
CF	0.56	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.56.[43]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a stand-alone or whole-house dehumidifier meeting the minimum effective federal standard for performance. Dehumidifiers manufactured and distributed in commerce on or after October 1, 2012 and before June 13, 2019 must meet the energy conservation standards shown in the table below, rated in Energy Factor, as specified in the Code of Federal Regulations.[44]

Product Capacity (pints/day)	Energy Factor (liters/kWh)
≤ 35	1.35
> 35 to ≤ 45	1.50
> 45 to ≤ 54	1.60
> 54 to ≤ 75	1.70
> 75 to ≤ 185	2.50

Dehumidifiers manufactured and distributed in commerce on or after June 13, 2019 must meet the energy conservation standards shown in the tables below, rated in Integrated Energy Factor as specified in the Code of Federal Regulations.[45]

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[42] Savings Calculator for ENERGY STAR® Qualified Appliances (accessed 1/18/2018)

[43] A. Mendyk & D. Cautley, Dehumidifier Metering Study, Home Energy, January 2011: Summer duty cycle used as a proxy for CF.

[44] 10 CFR 430.32(v)(1)

[45] 10 CFR 430.32(v)(2)

Stand-Alone Dehumidifiers	
Product Capacity (pints/day)	**Integrated Energy Factor (liters/kWh)**
≤ 25	1.30
> 25 to ≤ 50	1.60
> 50	2.80

Whole-House Dehumidifiers	
Product Case Volume (ft^3)	**Integrated Energy Factor (liters/kWh)**
≤ 8.0	1.77
> 8.0	2.41

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified stand-alone or whole-house dehumidifier. Prior to June 13, 2019, the compliance equipment's Energy Factor shall be taken from the application. If the equipment Energy Factor is unknown, ENERGY STAR® minimum qualifying specifications, as shown in the table below, may be used.[46]

Product Capacity (pints/day)	Energy Factor (liters/kWh)
< 75	2.00
≥ 75 to ≤ 185	2.80

On or after June 13, 2019, the compliance equipment's Integrated Energy Factor, which must exceed the performance metric of the baseline equipment, shall be taken from the application. To date, ENERGY STAR® qualifying criteria rated in Integrated Energy Factor have not been published. Until an updated ENERGY STAR® specification for dehumidifiers takes effect, the compliance condition Integrated Energy Factor must be taken from the application. Default values from future ENERGY STAR® qualifying product criteria may be used once effective. Until this measure can be updated to reflect these new standards, visit www.energystar.gov/ to check for updated eligibility specifications.

Operating Hours

The dehumidifier is assumed to be operating 1,632 hours per year based on 68 days of 24 hour operation.[47]

Effective Useful Life (EUL)

See Appendix P.

[46] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 4.0, February 2016
[47] Savings Calculator for ENERGY STAR® Qualified Appliances (accessed 1/18/2018)

Ancillary Fossil Fuel Savings Impacts

Reduction in energy usage will have a negligible impact on space heating. Consideration of these effects is not included in this methodology.

Ancillary Electric Savings Impacts

Reduction in energy usage will have a negligible impact on space heating. Consideration of these effects is not included in this methodology.

References

1. ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 4.0, February 2016.
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR_Dehumidifiers_V4%200_Specification_Final_1.pdf
2. A. Mendyk & D. Cautley, Dehumidifier Metering Study, Home Energy, January 5, 2011
   Available from: http://homeenergy.org/public/index.php/show/article/id/777/viewFull/
3. Savings Calculator for ENERGY STAR® Qualified Appliances
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
4. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
11-13-1	11/26/2013
3-18-12	3/29/2018

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AIR PURIFIER (CLEANER)

Measure Description

Room air purifiers - sometimes referred to as "room air cleaners" - are portable, electric appliances that remove fine particles, such as dust and pollen, from indoor air.[48] This measure applies to residential air purifiers (cleaners) meeting the minimum qualifying efficiency standards established under the ENERGY STAR® Program.[49]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta \text{kWh} = \text{units} \times (\text{kWh}_{baseline} - \text{kWh}_{ee})$$

$$\text{kWh}_{ee} = (8{,}760 - hrs) \times \frac{\text{standby}_{ee}}{1{,}000} + hrs \times \frac{CADR}{Eff_{ee} / 1{,}000}$$

$$kWh_{baseline} = (8{,}760 - hrs) \times \frac{standby_{baseline}}{1{,}000} + hrs \times \frac{CADR}{Eff_{baseline} / 1{,}000}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{\Delta kWh}{hrs}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed
ee	= Energy efficient condition or measure, per ENERGY STAR® eligibility criteria
baseline	= Baseline condition or measure
CF	= Coincidence factor
8,760	= Hours per year
standby	= Standby Power (Watts)
CADR	= Clean Air Delivery Rate (CADR), a measure of the amount of contaminant-free air delivered by the qualified air purifier (cubic feet per minute)[2]

[48] ENERGY STAR® Air Purifiers (Cleaners): https://www.energystar.gov/products/appliances/air_purifiers_cleaners/

[49] ENERGY STAR® Product Specification for Room Air Cleaners, Eligibility Criteria, V1.2, July 2011

Eff = Efficiency (dust CADR/Watt); the ENERGY STAR® specification for room air purifiers measures energy efficiency by using a Clean Air Delivery Rate-to-Watt ratio.[50]
hrs = Operating hours per year
1,000 = Conversion from W to kW

Summary of Variables & Data Sources

Variable	Value	Notes
CADR		Based on ENERGY STAR® manufacture rating
Eff_{ee}		Based on ENERGY STAR® manufacture rating (CADR/Watt)
$Eff_{baseline}$	1.0	CADR/Watt
$standby_{ee}$		Based on ENERGY STAR® manufacture rating (Watts)
$standby_{baseline}$	1.0	Watts
hrs	5,840	Based on ENERGY STAR® Calculator default assumptions[51]
CF	0.67	Assumes equal likelihood of usage at any time of day (16/24 hours)

Ratings are based on ENERGY STAR® Eligibility Criteria and the Savings Calculator for ENERGY STAR® Qualified Appliances.[4]

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.67.

Baseline Efficiencies from which Savings are Calculated

The baseline equipment is assumed to have an *Eff* of 1.0 CADR/Watt and a *standby* power of 1.0 Watts (from the ENERGY STAR® calculator default assumptions).

Compliance Efficiency from which Incentives are Calculated

Compliance requires a minimum *Eff* of 2.0 CADR/Watt and maximum *standby* power of 2.0 Watts per the ENERGY STAR® Product Specification for Room Air Cleaners. Additionally, qualified equipment must produce a minimum 50 CADR for dust, measured according to guidance provided in the latest ANSI/AHAM AC-1. Qualifying models that perform secondary consumer functions (e.g. clock, remote control) must meet the standby power requirement.[3]

[50] ENERGY STAR® Product Specification for Room Air Cleaners, Eligibility Criteria, V1.2, July 2011
[51] ENERGY STAR® Savings Calculator for ENERGY STAR® Qualified Appliances (last updated October 1, 2016) https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

Operating Hours

The energy savings calculations use 16 hours of operation per day, 365 days a year, totaling 5,840 hours/year, per the Savings Calculator for ENERGY STAR® Qualified Appliances.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Air Purifiers (Cleaners)
   Available from:
   https://www.energystar.gov/products/appliances/air_purifiers_cleaners/key_product_criteria
2. ENERGY STAR® Product Specification for Room Air Cleaners, Eligibility Criteria, V1.2, July 2011
   Available from:
   https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/room_air cleaners/Room_Air_Cleaners_Final_V1.2_Specification.pdf?a643-499a
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

Record of Revision

Record of Revision Number	Issue Date
6-17-11	6/30/2017

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DISHWASHER

Measure Description

This measure covers the installation of ENERGY STAR® qualified residential dishwashers.[52] A dishwasher is a cabinet-like appliance that, with the aid of water and detergent, washes, rinses, and dries (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, mechanical and/or electrical means and discharges to the plumbing drainage system. ENERGY STAR® rated machines run more efficiently while washing dishes through improved technology such as soil sensors, improved water filtration, more efficient jets, and innovative dish rack designs. Qualified dishwashers are 12% more efficient than non-certified models.[53]

This measure only applies to standard and compact residential grade equipment, as defined below.

Standard Dishwasher – A dishwasher that has a capacity equal to or greater than eight place settings plus six serving pieces as specified in ANSI/AHAM DW-1-2010 (incorporated by reference; see §430.3), using the test load specified in section 2.7 of 10 CFR 430, Subpart B, Appendix C1.[54]

Compact Dishwasher – A dishwasher that has a capacity of less than eight place settings plus six serving pieces as specified in ANSI/AHAM DW-1-2010 (incorporated by reference; see §430.3), using the test load specified in section 2.7 of 10 CFR 430, Subpart B, Appendix C1.[55]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times [(kWh_{baseline} - kWh_{ee}) \times (F_{machine} + F_{wh} \times ElecSF_{wh})]$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times (kWh_{baseline} - kWh_{ee}) \times F_{wh} \times GasSF_{wh} \times \frac{RE_{elec}}{RE_{gas}} \times \frac{3{,}412}{100{,}000}$$

[52] ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers Eligibility Criteria Version 6.0, January 2016
[53] Efficiency of ENERGY STAR® Dishwashers (accessed 4/4/2018) https://www.energystar.gov/products/appliances/dishwashers
[54] 10 CFR 430, Subpart B, Appendix C1
[55] Ibid

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
$\Delta therms$	= Annual gas energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
kWh	= Annual rated electric energy use
$F_{machine}$	= Fraction of energy used for the dishwasher machine
F_{wh}	= Fraction of energy used for the water heater
$ElecSF_{wh}$	= Electric Savings Factor for water heaters
$GasSF_{wh}$	= Gas Savings Factor for water heaters
RE_{elec}	= Recovery efficiency of electric water heater
RE_{gas}	= Recovery efficiency of gas water heater
CF	= Coincidence factor
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		Look up based on Dishwasher Type in Baseline Efficiencies section below.
kWh_{ee}		From application.
F_{wh}	0.56	Based on ENERGY STAR®.[56]
$F_{machine}$	0.44	Based on ENERGY STAR®.[57]
$ElecSF_{wh}$	Electric WH: 1.00 Gas WH: 0 Other: 0 Unknown: 0.31	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[58] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration of delivery mechanism.
$GasSF_{wh}$	Electric WH: 0 Gas WH: 1.00 Other: 0 Unknown: 0.56	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[59] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration of delivery mechanism.

56 ENERGY STAR® Appliance Calculator
57 Ibid
58 EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7 ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating)
59 EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7 ("Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating)

Variable	Value	Notes
RE_{elec}	0.98	Recovery efficiency of typical electric storage type water heater. [60]
RE_{gas}	0.75	Recovery efficiency of typical gas storage type water heater.[61]
hrs	301	Code of Federal Regulations. [62]
CF	0.026	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.031.[63]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a residential dishwasher as defined in the Measure Description section above with type equivalent to the efficient case meeting the minimum effective federal performance standards. The baseline water heating system is a standard efficiency storage type electric or gas system (fuel type equivalent to the actual existing condition). Current federal annual energy consumption performance standards for dishwashers are provided in the table below.[64]

Dishwasher Type	$kWh_{baseline}$
Compact	222
Standard	307

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified residential dishwasher as defined in the Measure Description section above. Qualifying equipment must have rated annual energy consumption at or below the ENERGY STAR® qualified specifications as indicated the table below, based on dishwasher type.[65] Energy rating is to be taken from application.

Dishwasher Type	kWh_{ee}
Compact	203
Standard	270

[60] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

[61] Per 10 CFR 430, typical recovery efficiency of a gas water heater is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.

[62] 10 CFR 430 Appendix C1 (5) Uniform Test Method for Measuring the Energy Consumption of Dishwashers

[63] Based on 8760 end use data for Missouri, provided to VEIC by Ameren for use in the Illinois TRM. The average dishwasher load during peak hours is divided by the peak load. In the absence of a New York specific load shape, this is deemed a reasonable proxy because load shapes are not expected to vary significantly by region. Data from Ameren was adjusted to account for the difference in assumed annual operating hours (252 hours were used in the referenced study whereas 301 hours are cited in this document).

[64] 10 CFR 430.32 (f)(1)

[65] ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers Eligibility Criteria Version 6.0, January 2016, Table 1: Annual Energy Consumption Base Allowances

Operating Hours

An average of 215 annual 1.4-hour dishwasher cycles is assumed in order to estimate conventional and qualifying energy ratings, for a total of 301 hours of active use per year. [66]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers, Eligibility Criteria Version 6.0, January 2016
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements_0.pdf
2. ENERGY STAR® Certified Products, Appliances, Dishwashers
   Available from: https://www.energystar.gov/products/appliances/dishwashers
3. 10 CFR 430 Subpart B Appendix C1 Uniform Test Method for Measuring the Energy Consumption of Dishwashers
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=aae04a703cdc86ce4c2f95a211f420f2&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.c1
4. Savings calculator for ENERGY STAR® Qualified Appliances
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
5. EIA Residential Energy Consumption Survey (RECS) 2015 Survey Data for Middle Atlantic States.
   Available from:
   https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.7.php
6. 10 CFR 430 Subpart B Appendix E Uniform Test Method for Measuring the Energy Consumption of Water Heaters
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e

[66] 10 CFR 430 Appendix C1 (5) Uniform Test Method for Measuring the Energy Consumption of Dishwashers

7. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=c46beaae860c6caba80d2be690e27cac&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-18-1	6/26/2018

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REFRIGERATOR AND FREEZER REPLACEMENT

Measure Description

This measure covers the replacement of inefficient residential grade refrigerators and freezers with ENERGY STAR® compliant equipment. Residential refrigerators and freezers include electric refrigerators, electric refrigerator-freezers, and freezers, having a source of refrigeration requiring single phase, alternating current electric energy input only. Known collectively as "refrigeration products," these appliances chill and preserve food and beverages, provide ice and chilled water, and freeze food.

This measure does not apply to refrigerators and refrigerator-freezers with a total refrigerated volume exceeding 39 ft^3 or freezers with a total refrigerated volume exceeding 30 ft^3.[67]

Savings are calculated between the energy consumption of the baseline unit and that of the more efficient replacement meeting ENERGY STAR® minimum performance specification of at least 10% lower energy consumption than that mandated by federal standards.[68]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_{baseline} - kWh_{ee}) \times (1 + HVAC_c) \times F_{occ}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{kWh_{baseline} - kWh_{ee}}{8{,}760}\right) \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times (kWh_{baseline} - kWh_{ee}) \times HVAC_g \times F_{occ}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
kWh	= Annual electric energy consumption
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption
F_{occ}	= Adjustment factor to account for number of occupants

[67] 10 CFR 430.32(a)

[68] ENERGY STAR® Refrigerators & Freezers Key Product Criteria

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

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		See Baseline Efficiencies section below.
kWh_{ee}		From application.
F_{occ}		See Occupant Adjustment Factor section below.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. If unknown, assume Single Family Home building type, New vintage, and AC with Gas Heat HVAC type. See Appendix D.
$HVAC_d$		HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. If unknown, assume Single Family Home building type, New vintage, and AC with Gas Heat HVAC type. See Appendix D.
$HVAC_g$		HVAC interaction factor for annual natural gas energy consumption (therms/kWh). Vintage and HVAC type weighted average by city. If unknown, assume Single Family Home building type, New vintage, and AC with Gas Heat HVAC type. See Appendix D.
CF	1.0	

Occupant Adjustment Factor (F_{occ})

The occupant adjustment factor is used to adjust the energy savings according to the number of occupants in the residence (if applicable), as shown in the table below. If unknown, apply 0 occupants as a default value.

Number of Occupants	F_{occ}[69]
0 occupants	1.00
1 occupant	1.05
2 occupants	1.10
3 occupants	1.13
4 occupants	1.15
5 or more	1.16

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[70]

[69] The Occupant Adjustment Factor is developed from simulating audits within the ORNL weatherization tool, National Energy Audit Tool (NEAT), Oak Ridge National Laboratory, 2012.
[70] *No source specified – update pending availability and review of applicable references.*

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a minimally code compliant refrigerator, refrigerator-freezer or freezer as defined in the Measure Description section above. Baseline annual electric consumption (kWh/yr) shall align with federally mandated maximum energy use associated with the Product Class and Adjusted Volume (AV in ft^3 or av in L) of the qualifying equipment. Federal standard annual electric consumption data is provided in the directory of ENERGY STAR® qualified Refrigerators[71] and Freezers[72] according to the make and model of the qualifying equipment. The values specified by ENERGY STAR® incorporate conversion from total capacity to Adjusted Volume as dictated by the Code of Federal Regulations.[73] For this reason, $kWh_{baseline}$ must be determined from the ENERGY STAR® directory.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified refrigerator, refrigerator-freezer or freezer as defined in the Measure Description section above. Annual energy consumption of the compliance condition shall be determined from the directory of ENERGY STAR® qualified Refrigerators[74] and Freezers[75] according to the make and model of the qualifying equipment.

Operating Hours

Refrigeration products are assumed to be plugged into an electrical outlet 8,760 hours per year. Compressor cycling is inherent in the specified annual energy consumption of baseline and qualifying equipment.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

High-efficiency refrigeration products reject less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. 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

High-efficiency refrigeration products reject less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. The HVAC

[71] ENERGY STAR® Certified Residential Refrigerators Product Finder https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[72] ENERGY STAR® Certified Residential Freezers Product Finder https://www.energystar.gov/productfinder/product/certified-residential-freezers/results
[73] 10 CFR 430 Subpart B, Appendices A and B
[74] ENERGY STAR® Certified Residential Refrigerators Product Finder https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
[75] ENERGY STAR® Certified Residential Freezers Product Finder https://www.energystar.gov/productfinder/product/certified-residential-freezers/results

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. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
2. ENERGY STAR® Refrigerators & Freezers Key Product Criteria, Sept 15, 2014 Available from: https://www.energystar.gov/products/appliances/refrigerators/key_product_criteria
3. Oak Ridge National Laboratory, National Energy Audit Tool (NEAT), 2012 Available from: https://weatherization.ornl.gov/obtain/
4. ENERGY STAR® Certified Residential Refrigerators Product Finder Available from: https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results
5. ENERGY STAR® Certified Residential Freezers Product Finder Available from: https://www.energystar.gov/productfinder/product/certified-residential-freezers/results
6. 10 CFR 430 Subpart B, Appendix A – Uniform Test Method for Measuring the Energy Consumption of Refrigerators, Refrigerator-Freezers, and Miscellaneous Refrigeration Products
Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.a
7. 10 CFR 430 Subpart B, Appendix B – Uniform Test Method for Measuring the Energy Consumption of Freezers
Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.b

Record of Revision

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1	10/15/2010
7-13-3	7/31/2013
7-13-41	7/31/2013
9-13-1	9/27/2013
3-18-7	3/29/2018

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Soundbar

Measure Description

This measure covers soundbars in residential applications meeting the minimum qualifying efficiency standards established under the ENERGY STAR® program, Program Requirements for Audio/Video Version 3.0, effective December 2014.[76] A soundbar is a mains-connected product that offers audio amplification housed in a wide horizontal enclosure. ENERGY STAR® rated soundbars have a lower power draw when in sleep and idle modes and a higher amplifier efficiency than conventional models.[77] Qualified soundbars use about 70% less energy than unqualified equipment.[78]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \ \times (kWh_{baseline} - \ kWh_{ee})$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therm = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
kWh	= Annual rated electric energy use
CF	= Coincidence factor
8,760	= Hours in one year

[76] ENERGY STAR® Program Requirements Product Specification for Audio/Video Eligibility Criteria Version 3.0, Rev. December 2014
[77] Consumer Messaging Guide for ENERGY STAR® Certified Consumer Electronics
[78] ENERGY STAR® Sound Bars (accessed 10/2/2018) https://www.energystar.gov/products/holiday/sound_bars

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$	77	Retail Products Platform. [79]
kWh_{ee}	29	Retail Products Platform. [80]
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[81]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a non-ENERGY STAR® qualified soundbar in a residential application.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified soundbar in a residential application with power performance specifications meeting or exceeding the requirements of ENERGY STAR® Program Requirements for Audio/Video Version 3.0, effective December 2014.[82]

Operating Hours

Soundbars are assumed to be plugged into an electrical outlet 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements Product Specification for Audio/Video, Eligibility Criteria Version 3.0, December 2014
   Available from:
   https://www.energystar.gov/sites/default/files/Final%20Version%203.0%20AV%20Program%20Requirements%20%28Rev%20Dec-2014%29.pdf

[79] Retail Products Platform: Product Analysis, Last updated May 25, 2016
[80] Retail Products Platform: Product Analysis, Last updated May 25, 2016 – ENERGY STAR® + 15% annual consumption increased by 15% to reflect minimum compliance with ENERGY STAR® Specification V3.0
[81] *No source specified – update pending availability and review of applicable references.*
[82] ENERGY STAR® Program Requirements for Audio/Video Version 3.0, December 2014

2. US EPA Consumer Messaging Guide for ENERGY STAR® Certified Consumer Electronics
   Available from:
   https://www.energystar.gov/ia/partners/downloads/CE_Consumer_Messaging.pdf
3. ENERGY STAR® Sound Bars
   Available from: https://www.energystar.gov/products/holiday/sound_bars
4. Retail Products Platform Product Analysis, Last Updated May 25, 2016.
   Available from:
   https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view

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12-18-6	12/28/2018

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APPLIANCE – CONTROL

ADVANCED POWER STRIP

Measure Description

This measure covers the installation of Tier 1 and Tier 2 advanced power strips (APS) installed in home entertainment centers (AV Equipment) and home offices (IT Equipment). An APS reduces energy consumption by shutting off the supply power to electronic devices when they are not in active use. This measure applies to power strips with 5 outlets or more.

Tier 1 APS, also known as master-controlled APS, are designed to reduce standby energy waste by monitoring the power state of a master device (typically a TV or desktop computer) using current-sensing technology and cutting power to controlled (or switched) devices when the master device is off. This reduces the energy and power consumption of interconnected equipment (i.e. entertainment centers and home offices) by eliminating standby loads and consumption of devices left on but not in use. Tier 1 APS applies to both home office and entertainment center equipment.

Tier 2 APS reduce active and standby energy waste by monitoring user engagement and cutting power to all devices when a set period of inactivity is detected. This is accomplished through the use of infrared (IR) sensing and motion-sensing technology, in addition to the master/switched capability of a Tier 1 APS. Active power waste occurs when electronic equipment is on, but the equipment is not being used. Standby power loss occurs when energy is consumed by equipment while it is turned off and in idle mode, but is still plugged in. Tier 2 APS realize savings by reducing both active and standby power loss, which can provide significant energy savings over a Tier 1 Advanced Power Strip. For the purposes of this measure, Tier 2 APS apply to entertainment center equipment only; there are no incremental savings associated with installation of a Tier 2 APS in a home office.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{hrs_{off}} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

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

Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
(ΔkWh/unit)	= Annual electric energy savings per unit
hrs_{off}	= Annual hours that the connected system is not in use or is turned off
CF	= Coincidence Factor

Summary of Variables & Data Sources

Variable	Value	Notes
(ΔkWh/unit)		Lookup based on tier, connected equipment type and existing condition in Annual Electric Energy Savings per Unit table below.
hrs_{off}	Tier 1: 7,340 Tier 2: 8,048	See Operating Hours section below
CF	0.8	

Annual Electric Energy Savings per Unit (ΔkWh/unit)

Annual electric energy savings are shown in the table below, where the Baseline condition is equivalent to the existing case and Connected Equipment is the type of equipment to be controlled with the installed APS. Unknown designations are provided for use in retailer or online market place point-of-sale programs, in which the application or existing condition is unknown.

APS Tier	Connected Equipment	Baseline	ΔkWh/unit
Tier 1	AV Equipment	Standard Power Strip	75.1[83]
Tier 1	IT Equipment	Standard Power Strip	31[84]
Tier 1	Unknown	Standard Power Strip	57.5[85]
Tier 2	AV Equipment	Standard Power Strip	234[86]
Tier 2	AV Equipment	Tier 1 Power Strip	158.9[87]
Tier 2	AV Equipment	Unknown	158.9[88]

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[89]

[83] New York State Energy Research and Development Authority, Advanced Power Strip Research Report, August 2011, p. 30.
[84] Ibid.
[85] Ibid, p. 7. Calculated with weighted average where 60% of Tier 1 APS applications are used for AV equipment and 40% for IT and other smaller load applications.
[86] San Diego Gas & Electric, Tier 2 Advanced Power Strips in Residential and Commercial Applications, April 2015, p. 3
[87] Ibid. Calculated as incremental savings over a Tier 1 APS (234 – 75.1 = 158.9 kWh).
[88] Ibid. Conservatively assumes savings associated with replacement of a Tier 1 APS.
[89] *No source specified – update pending availability and review of applicable references.*

Baseline System from which Savings are Calculated

The baseline condition for Tier 1 APS is AV or IT equipment plugged into a standard power strip. The baseline condition for Tier 2 APS is AV equipment plugged into either a standard power strip or Tier 1 APS.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a Tier 1 or Tier 2 APS as defined in the Measure Description above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

Power strips are assumed to be plugged in at all times. The hrs_{off} term used above for the purposes of estimating peak coincident demand savings adopts a usage profile associated with AV equipment, as this provides the most conservative demand savings estimate. This equipment is assumed to be off for 20.11 hours per day and on but not in use for 1.94 hours per day.[90] For Tier 1 APS, only off hours lead to savings, thus the operating hours are 365 x 20.11 = 7,340. Savings are achieved for Tier 2 APS when equipment is off or on but not in use. Thus, the hours of operation used to determine demand savings are 365 x (20.11 + 1.94) = 8,048. No savings are achieved during the remaining 712 hours per year when equipment is in active use. This reporting of AV off hours aligns well with the NYSERDA APS research study, which found television off hours to be 19.1 per day in New York State.[91]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. New York State Energy Research and Development Authority, Advanced Power Strip Research Report, August 2011
   Available from: https://www.nyserda.ny.gov/Residents-and-Homeowners/Your-Home/Power-Management

[90] California Plug Load Research Center, Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive, May 2014, p. 36
[91] New York State Energy Research and Development Authority, Advanced Power Strip Research Report, August 2011, p. 8

2. San Diego Gas & Electric, Tier 2 Advanced Power Strips in Residential and Commercial Applications, April 2015
Available from: http://www.etcc-ca.com/sites/default/files/reports/et14sdg8031_commerical_tier_2_aps.pdf
3. California Plug Load Research Center, Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive, May 2014
Available from: http://embertec.com/assets/pdf/CalPlug_Tier2_APS_Evaluation.pdf

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1	12/31/2015
1-17-2	12/31/2016
3-18-1	3/29/2018

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APPLIANCE RECYCLING

AIR CONDITIONER – ROOM (RAC) RECYCLING

Measure Description

In many cases where an air conditioning unit is replaced by a homeowner, the existing unit is retained, sold, or donated for use elsewhere and represents additional load on the grid. This measure covers recycling of the existing functional equipment, thereby eliminating the consumption associated with that equipment. Air conditioner recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing inefficient functional air conditioners from the electric grid. Only recycled equipment 5 years old or older are eligible for energy savings.

This measure covers the recycling of inefficient room air conditioners in residential applications. A room air conditioner is a consumer product, other than a "packaged terminal air conditioner," which is powered by a single phase electric current and which is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating.[92]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures recycled under the program
(BTU/h)/unit	= British Thermal Units per hour of air conditioning per unit
baseline	= Baseline condition or measure
CEER	= Combined Energy Efficiency Ratio

[92] 10 CFR 430.2

$EFLH_{cooling}$ = Equivalent cooling full-load hours
CF = Coincidence factor
1,000 = Conversion factor, one kW equals 1,000 Watts

Summary of Variables and Data Sources

Variable	Value	Notes
(BTU/h)/unit		From application, or use 7,829 as default.[93]
$CEER_{baseline}$		If known, use the nameplate efficiency of the recycled equipment, from application. Nameplate EER may be converted to CEER by dividing EER by 1.01 (EER/1.01 = CEER).[94] If unknown, see Baseline Efficiencies section below.
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup from Operating Hours section below based on location.
CF	0.3	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.3.[95] The average Seasonal CF based on 2007 weather data used for this measure aligns with results of a sampling study conducted in Con Edison territory, citing a CF = 0.31.[96]

Baseline Efficiencies from which Savings are Calculated

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

The CEER values listed in the table below reflect the minimum performance required by the Code of Federal Regulations effective October 1, 2000 to May 31, 2014.[97]

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93 RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008, p. 22 (based on population average)
94 Conversion factor developed by comparing EER and CEER values reported in ENERGY STAR® Program Requirements for Room Air Conditioners Version Eligibility Criteria 3.1
95 RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008, p. iv (based on average Seasonal CF for all load zones using 2007 weather data)
96 Northeast Energy Efficiency Partnerships, Loadshape Report and Catalogue
97 10 CFR 430.32(b), CFR EER values were converted to CEER values by dividing by 1.01. Conversion factor developed by comparing EER and CEER values reported in ENERGY STAR® Program Requirements for Room Air Conditioners Version Eligibility Criteria 3.1.

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

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

Cooling equivalent full load hours for residential room air conditioners shall be established based on location per the table below. $EFLH_{cooling}$ values below were determined by calculating the ratio of RAC cooling EFLH in Albany[98] to average cooling EFLH in Albany per Appendix G and applying it to the average EFLH for each city. EFLH was averaged from Appendix G over vintage and building type for each city.

City	$EFLH_{cooling}$
Albany	224
Binghamton	171
Buffalo	219
Massena	187
NYC	364
Poughkeepsie	282
Syracuse	226

Effective Useful Life (EUL)

See Appendix P.

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

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430.2 Definitions
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12
2. RLW Analytics, Final Report Coincidence Factor Study: Residential Room Air Conditioners. June 23, 2008
   Available from: http://www.puc.state.nh.us/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf
3. ENERGY STAR® Program Requirements Product Specification for Room Air Conditioners Eligibility Criteria Version 3.1
   Available from: https://www.energystar.gov/sites/default/files/specs/ENERGY%20STAR%20Version%203.1%20Room%20Air%20Conditioner%20Program%20Requirements.pdf
4. Northeast Energy Efficiency Partnerships, Loadshape Report and Catalogue
   Available from: http://neep.org/loadshape-report-and-catalogue
5. 10 CFR 430.32 Energy and water conservation standards and their compliance dates
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=6dc64a198ad50a16b0ff6af63189872b&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_132

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1	10/15/2010
7-13-37	7/31/2013
3-18-8	3/29/2018

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REFRIGERATOR AND FREEZER RECYCLING

Measure Description

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

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

This measure does not cover the recycling of equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer". This refers to any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 ft^3 (220 liters), where the total refrigerated volume has been determined in accordance with the procedure prescribed in Appendix A (refrigerators and refrigerator-freezers) or B (freezers) of 10 CFR 430 Subpart B.[99]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

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

[99] 10 CFR 430.2

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

Summary of Variables and Data Sources

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

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

Variable	Value	Notes
(ΔkWh/unit)	Primary Refrigerator: 1,218 Secondary Refrigerator: 794 Freezer: 846	Refrigerator based on Cadmus memo to Consolidated Edison. [100] Freezer based on Energy & Resource Solutions[101]
TAF	1.22	Temperature Adjustment Factor; reflects load variance during summer peak due to increased ambient temperature conditions.[102]
LSAF	1.06	Load Shape Adjustment Factor; reflects the instantaneous differential from annual average load coincident with peak.[103]
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[104]

[100] Cadmus memo to Consolidated Edison, “Recommended Gross Savings Values for Refrigerator Recycling Programs”, December 17, 2015

[101] Based on Energy & Resource Solutions “Con Edison EEPS Programs - Impact Evaluation of Residential Appliance Bounty Program”, May 2015. Gross unit consumption of 1,267 kWhs x part use factor of 0.685 = 846 kWhs

[102] Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004. It assumes 58% of New York homes have central air conditioning.

[103] Ibid.

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

Baseline Efficiencies from which Savings are Calculated

The savings calculations above apply to recycling of a functioning primary[105] or secondary refrigerator, refrigerator-freezer or freezer with total refrigerated volume of 7.75 ft^3 (220 liters) or more.

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

References

1. 10 CFR 430.2 Definitions.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=433d4d2525eac3e38a1ede79f3b5c0ed&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12
2. Cadmus memo to Consolidated Edison, "Recommended Gross Savings Values for Refrigerator Recycling Programs", December 17, 2015
3. Con Edison EEPS Programs – Impact Evaluation of Residential Appliance Bounty Program, Energy & Resource Solutions (ERS), May 4, 2015
   Available from:
   http://legacyold.coned.com/energyefficiency/PDF/ConEd_Residential_Appliance_Bounty_Program_Final_Report.pdf

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

4. Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004
Available from: https://nascsp.org/wp-content/uploads/2018/02/blasnik_measurement-and-verification-of-residential-refrigerator.pdf
5. National Renewable Energy Laboratory, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 7: Refrigerator Recycling Evaluation Protocol, April 2013.
Available from: https://www.energy.gov/sites/prod/files/2013/05/f0/53827-7.pdf

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2	10/15/2010
7-13-4	7/31/2013
9-13-2	9/2/2013
6-15-2	6/1/2015
12-17-2	12/31/2017

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BUILDING SHELL

AIR LEAKAGE SEALING

Measure Description

This measure covers the installation of caulking, gasketing and weather stripping in the building envelope to reduce the natural infiltration rate in residential buildings. 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 excludes gut rehab projects, which shall be considered new construction.

The exterior envelope joints and seams should be visually inspected and all gaps sealed. The following items shall be inspected, and may be implemented based upon inspection results and/or program eligibility requirements:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space
- Caulk and seal air leaks where plumbing, ducting, or electrical wiring comes through walls, floors, ceilings, and soffits over cabinets.
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur.

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

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

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

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

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
ΔCFM_{50}		From application, results from blower door test.
F_n	19	Building Performance Institute. [106]
F_h	1 story: 1 1.5 stories: 0.89 2 stories: 0.81 2.5 stories: 0.76 3+ stories: 0.72	Based on the number of stories in the building.[107]
ΔkWh/CFM		Look up from Appendix E based on HVAC type and city.
ΔkW/CFM		Look up from Appendix E based on HVAC type and city.
Δtherms/CFM		Look up from Appendix E based on HVAC type and city.
ft^2		From application
$\Delta kWh/1{,}000ft^2$		Look up from Appendix E based on city and building vintage.
$\Delta kW/1{,}000ft^2$		Look up from Appendix E based on city and building vintage.
$\Delta therms/1{,}000ft^2$		Look up from Appendix E based on city and building vintage.
CF	0.69	

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[108]

Baseline Efficiencies from which Savings are Calculated

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

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[106] BPI Technical Standards for the Building Analyst Professional, January 2012, pg.5. Default F_n, or N factor, suggested for New York.
[107] BPI Technical Standards for the Building Analyst Professional, January 2012, pg. 5.
[108] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee.

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a building envelope with air sealing adequate to meet all applicable requirements of air leakage sealing per the Measure Description.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Building Performance Institute, Technical Standards for the Building Analyst Professional, January 2012.
   Available from:
   http://bpi.org/sites/default/files/Technical%20Standards%20for%20the%20Building%20Analyst%20Professional.pdf
2. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
3. ECCCNYS 2016, per IECC 2015; Section C402.5.1.3 Air Barrier Testing
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
4. NYCECC 2016; Section C402.5.1.3 Air Barrier Testing
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
5. ECCCNYS 2016, per IECC 2015; Section R402 Building Thermal Envelope
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency
6. NYCECC 2016; Section R402 Building Thermal Envelope
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016

7. 2017 NYS Uniform Code Supplement; Section 2.34 2015 IRC Section N1102.4.1 ((R402.4.1) Building thermal envelope)
Available from:
https://www.dos.ny.gov/DCEA/pdf/2017%20Uniform%20Code%20Supplement-10-2017.pdf
8. IMC 2015; Section 401.2 Ventilation Required
Available from: https://codes.iccsafe.org/public/document/IMC2015NY-1/chapter-4-ventilation

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1	10/15/2010
7-13-25	7/31/2013
9-18-19	9/30/2018
12-18-2	12/28/2018

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HOT WATER AND STEAM PIPE INSULATION

Measure Description

This measure covers the installation of fiberglass, rigid foam and cellular glass pipe insulation on uninsulated copper or steel piping with a nominal diameter between 0.75” and 4.00” in hot water and steam space heating and domestic hot water (DHW) distribution systems in residential buildings. Estimation of energy savings depends on the type and size of the pipe, type and thickness of the insulation, hot water temperature and ambient temperature.

This measure is applicable in retrofit applications only and must be installed by a qualified contractor complying with all relevant construction and safety codes and standards. Only insulation materials certified and rated in accordance with all pertinent ASTM thermal insulation standards may be installed under this measure. This measure is restricted to lengths of existing uninsulated piping in unconditioned spaces only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,gas} \times 100{,}000} \times l \times \Delta T \times hrs \times GasSF$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
baseline = Baseline condition or measure
ee = Energy efficient measure
(UA/L) = Overall heat transfer coefficient per unit length (BTU/h-°F-ft)
E_t = Thermal efficiency of hot water source
l = Length of installed insulation (ft)
ΔT = Temperature difference between hot water in pipe and surrounding ambient air temperature (°F)
hrs = Annual operating hours
ElecSF = Electric Savings Factor: Adjustment to electric energy savings based on fuel type

GasSF = Gas Savings Factor: Adjustment to gas energy savings based on fuel type
CF = Coincidence factor
3,412 = Conversion factor, one kW equals 3,412 BTU/h
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
$(UA/L)_{baseline}$		Lookup from Baseline Efficiencies section below, based on pipe diameter, pipe material and application.
$(UA/L)_{ee}$		Lookup from Compliance Efficiency section below, based on pipe diameter and insulation type and thickness.
$E_{t,elec}$	DHW: 0.98	Recovery efficiency of typical electric storage type water heater.[109]
$E_{t,gas}$	DHW: 0.75 HW Boiler: 0.82 AFUE Steam Boiler: 0.80 AFUE	Recovery efficiency of typical gas storage type water heater and baseline efficiency of residential-size space heating boilers. [110,111]
l		From application
ΔT	$T_{pipe} – T_{amb}$	
T_{pipe}	DHW: 140 HW Boiler: 160 Steam Boiler: 212	Average temperature of hot water in distribution system piping (°F). [112]
T_{amb}	DHW: 70 Space Heat: 50	Surrounding average ambient air temperature (°F). [113,114]
ElecSF	Electric WH: 1.00 Gas WH: 0 Unknown WH: 0.31 Space Heat: 0	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[115] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration or delivery mechanism.

[109] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*
[110] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[111] 10 CFR 430.32(e)
[112] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
[113] Average annual ambient temperature in unconditioned spaces
[114] Average ambient temperature based on typical heating season conditions of unconditioned basements
[115] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7, Fuel used by main water heater ("Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating)

Variable	Value	Notes
GasSF	Electric WH: 0 Gas WH: 1.00 Unknown WH: 0.56 Space Heat: 1.00	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[116] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration or delivery mechanism.
hrs	DHW: 8,760 Space Heat: $EFLH_{heating}$ (Appendix G)	See Operating Hours section below.
CF	DHW: 1.0 Space Heat: N/A	

Coincidence Factor (CF)

The prescribed value for the coincidence factor for domestic water heating is 1.0.[117]
The prescribed value for the coincidence factor for space heating is N/A.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a length of uninsulated copper or steel domestic hot water or space heating piping located in an unconditioned space. Prescribed $(UA/L)_{baseline}$ values are provided in the table below based on the diameter of pipe, pipe material, and application. Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Values were developed using NAIMA's 3E Plus software program.[118] Insulation of CPVC, PEX and HDPE piping is not eligible for savings under this measure; however, these pipe materials are under evaluation for future inclusion.

Pipe Diam. (in)	$(UA/L)_{baseline}$				
	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45

[116] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7, fuel used by main water heater ("Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating)
[117] *No source specified – update pending availability and review of applicable references.*
[118] Insulation Institute, 3E Plus® Version 4.1

Pipe Diam. (in)	(UA/L)$_{baseline}$				
	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
4.00	1.98	2.14	2.40	2.43	2.73

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a length of copper or steel service hot water or space heating hot water/steam distribution piping insulated in accordance with ECCCNYS[119] and NYCECC[120], which require hot water piping with 0.75" nominal diameter and larger to be insulated with a minimum thermal resistance of R-3. The R-value is the thermal resistance of the insulating material, which is derived by dividing the thickness of the material by the material's thermal conductivity, or k-value. Thermal transmittance, or the material's U-factor, is the inverse of the R-value.

The (UA/L)$_{ee}$ values associated with fiberglass, rigid foam and cellular glass insulation of various thicknesses provided in the table below shall be used to establish the compliance condition heat transfer coefficient. Pipe diameter and insulation type and thickness shall be taken from the application. The values below were calculated using a k-value of 0.25 BTU-in/h-°F-ft^2 for fiberglass and 0.35 BTU-in/ h-°F-ft^2 for rigid foam and cellular glass insulation at 100°F. Pipe wall resistance and exterior film resistance were ignored in the derivation of the values below. Values were developed using NAIMA's 3E Plus software program.[121]

Pipe Diam. (in)	(UA/L)$_{ee}$											
	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19

Operating Hours

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

Operating hours for water and steam boilers in space heating systems are established on the basis of equivalent full-load hours. Heating equivalent full-load hours were calculated from a DOE-2.2

[119] ECCCNYS 2016, R403.5.3
[120] NYCECC 2016, R403.5.3
[121] Insulation Institute, 3E Plus® Version 4.1

simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY by location, building type and vintage are tabulated in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
2. 10 CFR 430 Subpart B – Test Procedures, Appendix C1 - Uniform Test Method for Measuring the Energy Consumption of Dishwashers
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=9acb5e05dd1d96230c64079cf0c03102&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.c1
3. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
4. OSHA Legionnaire’s Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from:
   https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
5. EIA Residential Energy Consumption Survey (RECS) 2015 Survey Data for Middle Atlantic States, February 2015
   Available from:
   https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.7.php
6. 3E Plus, NAIMA, Insulation Institute, Version 4.1
   Available from: https://insulationinstitute.org/tools-resources/free-3e-plus/
7. ECCCNYS 2016, per IECC 2015; R403.5.3 Hot water pipe insulation (Prescriptive)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency

8. NYCECC 2016; R403.5.3 Hot water pipe insulation (Prescriptive)
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016

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1	10/15/2010
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6-18-2	6/26/2018

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Opaque Shell Insulation

Measure Description

This measure covers the installation of wall and ceiling insulation to reduce the thermal conductance of the building envelope. Energy and demand saving are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured in order to estimate energysavings. This measure is only applicable as a retrofit in existing single and multi-family buildings. This excludes gut rehab projects, which shall be considered new construction.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
ft^2		From application.

Variable	Value	Notes
ΔkWh/1,000ft^2		Look up based on building type, location, HVAC type, insulation type and existing and installed insulation R-values in Appendix E.
ΔkW/1,000ft^2		Look up based on building type, location, HVAC type, insulation type and existing and installed insulation R-values in Appendix E.
Δtherms/1,000ft^2		Look up based on building type, location, HVAC type, insulation type and existing and installed insulation R-values in Appendix E.
CF	0.69	

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[122]

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

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

Opaque shell insulation improvements performed under this measure shall be installed such that all altered envelope components spaces comply with all applicable federal, state and local code requirements, including but not limited to Section R402 of ECCCNYS 2016[123] and NYCECC

[122] 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.
[123] ECCCNYS 2016, Section R402 Building Thermal Envelope

2016[124]. Thermal envelope components not altered as part of this measure (e.g. continuous insulation in wood-framed buildings) are not required to meet code for compliance.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

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

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[124] NYCECC 2016, Section R402 Building Thermal Envelope

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

Measure Description

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CFM	= Cubic foot per minute
HDD	= Heating degree day
$Eff_{heating}$	= Efficiency of heating system
1.08	= Specific heat of air × density of inlet air @ 70˚F × 60 min/hr[125]
24	= Hours in one day
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU's

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

Summary of Variables and Data Sources

Variable	Value	Notes
CFM	19	Based on a negative pressure differential of 10 Pa.[126,127]
HDD		Look up in Heating Degree Days section below based on location.
$Eff_{heating}$		From application, or look up in table below based on equipment type and size. For electric resistance heat, use a value of 1.0.

Heating Degree Days

The table below presents the heating degree days (HDD) for several NY cities throughout the heating season (October 1st through May 31st).[128] Heating degree days represent the annual summation of the number of degrees that each day's average temperature is below some baseline temperature. The baseline temperature reflects the temperature below which it is assumed a building needs to be heated. The HDD values below are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using a baseline temperature of 65° F.[129]

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

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

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

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

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

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

Systems Serving Single Units[130]

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

The baseline efficiency for heating systems serving multiple dwelling units is defined by International Energy Conservation Code[131] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) and the New York City Energy Conservation Code[132] (NYCECC) as shown in the table below.

Systems Serving Multiple Dwelling Units

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.78 AFUE	0.78 AFUE
	≥ 225 kBTU/h	0.80 Et	0.80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec	0.80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.80 AFUE	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et	0.80 Et
	> 2,500 kBTU/h	0.82 Ec	0.82 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et	0.79 Et
	> 2,500 kBTU/h	0.79 Et	0.79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et	0.77 Et
	> 2,500 kBTU/h	0.77 Et	0.77 Et

[130] 10 CFR 430.32(e)
[131] ECCCNYS 2016, Table C403.2.3(4) & Table C403.2.3(5)
[132] NYCECC 2016, Table C403.2.3(4) & Table C403.2.3(5)

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a room air conditioning unit in a multifamily building with a cover and/or sealing on the surrounding gap, as described in the Measure Description above, through the heating season (October 1st through May 31st).[133]

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

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Record of Revision

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6-14-1	6/19/2014
9-18-3	9/28/2018

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WINDOW REPLACEMENT

Measure Description

ENERGY STAR® windows with reduced thermal conductance and solar heat gain coefficient are an assembled unit consisting of a frame/sash component holding one or more pieces of glazing functioning to admit light and/or air into an enclosure and designed for a vertical installation in an external wall of a residential building.[134]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{ft^2}{100} \times \frac{\Delta kWh}{100\ ft^2} \times \frac{SEER_{baseline}}{SEER_{part}} \times \left[\frac{\overline{Eff}_{dist,baseline}}{\overline{Eff}_{dist,part}}\right]_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{ft^2}{100} \times \frac{\Delta kW}{100\ ft^2} \times \frac{EER_{baseline}}{EER_{part}} \times \left[\frac{Eff_{dist,pk,baseline}}{Eff_{dist,pk,part}}\right]_{cooling} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{ft^2}{100} \times \frac{\Delta therms}{100\ ft^2} \times \frac{AFUE_{baseline}}{AFUE_{part}} \times \left[\frac{\overline{Eff}_{dist,baseline}}{\overline{Eff}_{dist,part}}\right]_{heating}$$

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
ft^2	= Glazing area (in ft^2)
EER	= Energy efficiency ratio under peak conditions
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
AFUE	= Annual fuel utilization efficiency
CF	= Coincidence factor
$_{part}$	= Participant
$_{dist}$	= Distribution
Eff	= Energy efficiency (0 -100%)
$\overline{Eff}$	= Average energy efficiency (0 -100%)

[134] ENERGY STAR® Product Specification Residential Windows, Doors, and Skylights, Eligibility Criteria, V6.0, January 2014

Summary of Variables and Data Sources[135]

Variable	Value	Notes
$area_g$		Glazing area from application
$\Delta kWh/100ft^2$		HVAC type weighted average by city, use existing window type or vintage default for baseline.
$\Delta kW/100ft^2$		HVAC type weighted average by city, use existing window type or vintage default for baseline.
$\Delta therms/100ft^2$		HVAC type weighted average by city, use existing window type or vintage default for baseline.
$EER_{baseline}$	11.1	EER used in the simulations
EER_{part}		EER of cooling systems within participant population, average defaults to $EER_{baseline}$ (no adjustment)
$SEER_{baseline}$	13	SEER used in the simulations[136]
$SEER_{part}$		SEER of cooling system within participant population, average defaults to $SEER_{baseline}$ (no adjustment)
$AFUE_{baseline}$	0.80	AFUE used in the simulations[137]
$AFUE_{part}$		AFUE of heating system within participant population, average defaults to $AFUE_{baseline}$ (no adjustment)
$\overline{Eff}_{dist,baseline}$	0.956	Distribution system seasonal efficiency used in simulations
$\overline{Eff}_{dist,part}$		Distribution system seasonal efficiency within participant population, average defaults to $\bar{\eta}_{dist,baseline}$ (no adjustment)
$Eff_{dist,pk,baseline}$	0.956	Distribution system efficiency under peak conditions used in simulation
$Eff_{dist,pk,part}$		Distribution system efficiency under peak conditions within participant population, average defaults to $\eta_{dist,pk,baseline}$ (no adjustment)
CF	0.69	

Unit energy and demand savings calculated from the building prototype simulation models are shown in Appendix F. The savings are tabulated by location, building type, and HVAC system type for a variety of combinations of existing window and improved window types.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[138]

[135] Due to schedule of revisions, values specified here may not align with those presented throughout appendices.
[136] 10 CFR 430.32 (c)(1)(i) – Assumes a 3-ton split AC.
[137] 10 CFR 430.32 (e)(2)(i)(A) – Assumes an 80 kBTU/h output gas furnace.
[138] 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 the Mid-Atlantic TRM Version 6.0 published May 2016. MD factor used as approximation for NY-specific value.

Baseline Efficiencies from which Savings are Calculated[3]

A variety of existing window combinations are shown in the unit savings tables in Appendix F, including single pane clear glass, double pane clear and a minimally code compliant window. Energy savings are estimated based on the characteristics of the existing window. Single pane clear glass is the default for the old vintage, while double pane clear glass is the default for the average vintage. The minimally code compliant window is assumed to be the base case for new construction or window replacement projects.

Compliance Efficiency from which Incentives are Calculated

A typical window meeting the current ENERGY STAR® specifications is assumed to be the installed measure. The specifications assumed are listed below.[139]

U-Value (BTU/h-ft^2-ºF)	Solar Heat Gain Coefficient (SHGC)
≤ 0.27	Any
0.28	≥ 0.32
0.29	≥ 0.37
0.30	≥ 0.42

Operating Hours

The energy savings for windows are dependent on the HVAC system operating hours and thermostat set points. See Appendix A for the modeling assumptions for each building prototype.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

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[139] ENERGY STAR® Product Specification Residential Windows, Doors, and Skylights, Eligibility Criteria, V6.0, January 2014

2. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
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1	10/15/2010
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DOMESTIC HOT WATER

HEAT PUMP WATER HEATER (HPWH) – AIR SOURCE

Measure Description

This measure covers the installation of electric storage tank water heaters that use heat pump technology to move heat from the air (inside or outside the building) to the water storage tank and are designed to heat and store potable water at a thermostatically controlled temperature of less than 180°F. It is not intended for equipment delivering process or space heating hot water. It applies to electric heat pump water heaters with a maximum current rating of 24 amperes at a voltage no greater than 250 volts and with a rated storage tank capacity of 120 gallons or less.[140,141]

This measure applies to new construction/major renovation projects and replacement of existing electric water heaters and assumes baseline to be a minimally code compliant electric storage type water heater.

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

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

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

Peak Coincident Demand Savings

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

140 ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2, September 2017

141 10 CFR 430.2

Annual Gas Energy Savings

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
GPD	= Gallons per day
ΔT_{main}	= Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
UEF	= Uniform energy factor
F_{derate}	= Efficiency derating factor used to account for the degradation of heat pump performance present in systems installed in unconditioned spaces
$\Delta kWh_{cooling}$	= Annual electric cooling energy savings as a result of interactivity with the building’s HVAC system (electric cooling bonus)
$\Delta kWh_{heating}$	= Annual electric heating energy savings as a result of interactivity with the building’s HVAC system (electric heating penalty)
$F_{ElecHeat}$	= Electric heating factor, used to exclude electric heating penalty if no electric heating is present
F_{Loc}	= Installation location factor, used to exclude interactive HVAC impacts for systems installed in unconditioned spaces
F_{Cool}	= Cooling factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that reduces space cooling load
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
F_{Heat}	= Heating factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that increases space heating load
HSPF	= Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt-hour)
$F_{GasHeat}$	= Gas heating factor, used to exclude gas heating penalty if no gas heating is present
AFUE	= Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
(ΔkW/unit)	= Deemed peak coincident demand savings per measure
365	= Days in one year
8.33	= Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412	= Conversion factor, one kWh equals 3,412 BTU
3.412	= Conversion factor, one watt-hour equals 3.412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[142]
ΔT_{main}	T_{set} - T_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F).
T_{set}	140	Water heater set point temperature (°F).[143]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
$UEF_{baseline}$		Uniform Energy Factor of the baseline condition. See Baseline Efficiencies… section below for details regarding derivation of this input.
UEF_{ee}		Uniform Energy Factor of the energy efficient measure, from application.
F_{derate}		For equipment installed in unconditioned spaces, lookup in Derate Factor table below based on installation location and nearest city. For equipment installed in conditioned spaces, a value of 1.0 shall be used.
$F_{ElecHeat}$		Use a value of 1.0 if the building is electrically heated. Otherwise, use 0.0.
F_{Loc}		Use a value of 1.0 if the water heater is installed in a conditioned space. Otherwise, use 0.0.
F_{Cool}		Lookup in HVAC Interactivity table below based on nearest city.
SEER	13	Assumed efficiency of existing air conditioning system, based on a minimally code compliant, 3-ton, split system AC.[144]
F_{Heat}		Lookup in HVAC Interactivity table below based on nearest city.
HSPF	Heat Pump: 8.2 Electric Resistance: 3.412	Assumed efficiency of electric heating system, based on a COP of 1.0 for electric resistance heating and a minimally code compliant, 3-ton split system HP for heat pumps.[145]
$F_{GasHeat}$		Use a value of -1.0 if the building is gas heated. Otherwise, use 0.0.

[142] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
[143] Per OSHA recommendations for prevention of Legionalla bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.htm)
[144] ECCCNYS 2016, Table C403.2.3(1) & NYCECC 2016, Table C403.2.3(1)
[145] ECCCNYS 2016, Table C403.2.3(2) & NYCECC 2016, Table C403.2.3(2)

Variable	Value	Notes
AFUE	0.80	Assumed efficiency of gas heating system, based on a minimally code compliant, 80 kBTU/h output gas furnace.[146]
(ΔkW/unit)	0.17	Deemed peak coincident demand savings[147]

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

City	Annual average outdoor temperature[149] (°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

Derate Factor

Standard testing conditions for rating of heat pump water heaters require a dry bulb temperature of 67.5°F ± 1°F and a relative humidity of 50% ±2%.[150] The reported efficiency of heat pump water heaters is established at these conditions; however, heat pump efficiency degrades at lower ambient temperatures. The Derate Factor is established to adjust the published efficiency of the qualifying heat pump water heater when the system is installed in semi-conditioned or unconditioned spaces, namely, garages and basements. The values shown below were derived from Table 10 of Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates published by Bonneville Power Administration in 2011[151] and verified via comparison with results from the 2013 NEEA Heat Pump Water Heater Field Study Report.[152] Average values from northwest heating zones 1 (<6,000 HDD), 2 (6,000 – 7,500 HDD) and 3 (>7,500 HDD)[153] from this analysis and comparison were then mapped to representative NY climate regions as shown below.

[146] 10 CFR 430.32 (e) (2) (i) (A)
[147] "Field Testing of Pre-Production Prototype Heat Pump Water Heaters" Federal Energy Management Program, DOE/EE-0317, May 2007.
[148] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[149] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals
[150] 10 CFR 430 Subpart B Appendix E
[151] Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates, Bonneville Power Administration, November 2011
[152] NEEA Heat Pump Water Heater Field Study Report, Fluid Market Strategies, October 2013
[153] NW Council Heating/Cooling zone maps

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

HVAC Interactivity

Because heat pump water heaters operate via the transfer of heat from the ambient air to the water in the storage tank, systems installed in conditioned spaces will interact with the building's HVAC system. The values shown in the table below reflect the percentage of heat extracted from the ambient air by the heat pump that either decreases the building's cooling load (F_{Cool}) or increases the building's heating load (F_{Heat}). These values were derived from Table 12 of Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates published by Bonneville Power Administration in 2011[154] and key operating assumptions specified therein. Average values from northwest heating zones 1 (<6,000 HDD), 2 (6,000 – 7,500 HDD) and 3 (>7,500 HDD)[155] were then mapped to representative NY climate regions and scaled linearly based on regional HDD and CDD. The HDD and CDD values are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using base 65° F.[156]

City	CDD	F_{Cool}	HDD	F_{Heat}
Albany	597	0.26	6,680	0.70
Binghamton	382	0.17	7,193	0.76
Buffalo	544	0.24	6,617	0.70
Massena	363	0.16	8,196	0.84
NYC	1,160	0.51	4,671	0.49
Poughkeepsie	671	0.29	6,210	0.65
Syracuse	570	0.25	6,651	0.70

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a minimally code compliant electric storage water heater with storage

[154] Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates, Bonneville Power Administration, November 2011
[155] NW Council Heating/Cooling zone maps
[156] HDD/CDD taken from NCEI 1981-2010 climate normals

tank capacity and draw pattern equivalent to the efficient water heater. $UEF_{baseline}$ shall be calculated as a function of qualifying equipment tank volume (v_t) per federal standards[157] as shown in the table below, using the qualifying equipment capacity and draw pattern. Draw pattern can be established based on the efficient equipment First Hour Rating (FHR), rated in gallons. See First Hour Rating vs. Draw Pattern table below. If FHR is unknown, a Medium draw pattern should be assumed for equipment with rated storage capacity ≤50 gallons and a High draw pattern should be assumed otherwise.[158]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x v_t)
		Low	0.9254 - (0.0003 x v_t)
		Medium	0.9307 - (0.0002 x v_t)
		High	0.9349 - (0.0001 x v_t)
	> 55 gal and ≤ 120 gal	Very Small	1.9236 - (0.0011 x v_t)
		Low	2.0440 - (0.0011 x v_t)
		Medium	2.1171 - (0.0011 x v_t)
		High	2.2418 - (0.0011 x v_t)

*v_t = tank volume in gallons

First Hour Rating vs. Draw Pattern[159]

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a heat pump water heater meeting minimum performance requirements specified in ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2.[160] Per that specification, heat pump water heaters with ≤55 gallon storage capacity must have a UEF ≥ 2.00 and heat pump water heaters with >55 gallon storage capacity must have UEF ≥2.20.

Operating Hours

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

[157] 10 CFR 430.32(d)
[158] Based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
[159] 10 CFR 429.17
[160] ENERGY STAR® Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria Version 3.2, September 2017

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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INDIRECT WATER HEATER

Measure Description

This measure covers the installation of a gas indirect-fired storage water heating system in which the stored water is heated via hot water produced by a gas boiler rather than direct input from electric elements or gas burners. In such a system, a heat exchanger separates the potable water in the water heater from the boiler water. This measure applies to indirect-fired systems comprising a boiler with input heating capacity less than 300,000 BTU/h and a storage tank with a capacity of 20 to 120 gallons installed in residential applications. Larger equipment installed in whole building or multi-unit multifamily settings shall use the Commercial and Industrial Indirect Water Heater measure detailed in this document.

This measure estimates savings associated with the delivery of potable hot water only and assumes the installation of zone priority controls to interrupt demand for space heating hot water until domestic hot water demand is met.

This measure assumes baseline to be a minimally code compliant gas storage type water heater with storage capacity equivalent to the efficient water heater.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) + \left(\frac{UA_{baseline}}{Eff_{baseline}} - \frac{UA_{ee}}{Eff_{ee}}\right) \times \frac{\Delta T_{amb}}{100{,}000} \times 8{,}760\right]$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
GPD = Gallons per day
ΔT_{main} = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb} = Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)

baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
Eff	= Efficiency
UA	= Overall heat loss coefficient (BTU/h-°F)
365	= Days in one year
8.33	= Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU
8,760	= Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[161]
ΔT_{main}	T_{set} - T_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	70 = T_{set} - T_{amb}	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
T_{set}	140	Water heater set point temperature (°F).[162]
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).[163]
$Eff_{baseline}$	0.75	Efficiency of the baseline condition.[164]
Eff_{ee}		Efficiency of energy efficient indirect-system boiler (AFUE), from application.
$UA_{baseline}$	7.85	Overall heat loss coefficient of the baseline condition (BTU/h-°F).[165]

[161] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
[162] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
[163] 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.
[164] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[165] 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.

Variable	Value	Notes
UA_{ee}		Overall heat loss coefficient of the energy efficient measure (BTU/h-°F). Calculate per Qualifying Heat Loss Coefficient section below, based on qualifying equipment standby loss specification, rated in °F/hr. If unknown, assume UA_{ee} = 5.4.[166]

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

City	Annual average outdoor temperature[168] (°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

Qualifying Heat Loss Coefficient (UA_{ee})

Indirect-fired water heater storage tanks are tested and rated for standby losses (in °F/hr) at standard testing conditions in accordance with testing standards.[169] The qualifying equipment standby loss specification (SL_{ee}), where available, shall be used in the formula below, along with tank volume (v_{ee}) to establish the qualifying equipment heat loss coefficient (UA_{ee}).

$$UA_{ee} = \frac{SL_{ee}}{70} \times v_{ee} \times 8.33$$

where:

UA_{ee} = Overall heat loss coefficient (BTU/h-°F) of the energy efficient condition or measure

SL_{ee} = Standby loss specification (°F/hr) of the energy efficient condition or measure

v_{ee} = Rated storage capacity (gallons) of the energy efficient condition or measure

70 = Temperature differential (°F) utilized in standby loss testing procedure

8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit

166 Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory.

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

168 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

169 GAMA Testing Standard: Performance of Indirect-Fired Water Heaters, March 2003

Coincidence Factor (CF)

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

Baseline Efficiencies from which Incentives are Calculated

The baseline condition is a minimally code compliant gas storage type water heater with a recovery efficiency of 75%, tank volume equal to the energy efficient condition and heat loss coefficient as indicated above.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an indirect gas-fired water heating system meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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Record of Revision

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0	10/15/2010
6-13-2	6/30/2013
7-13-5	7/31/2013
7-13-6	7/31/2013
7-13-29	7/31/2013
7-13-33	7/31/2013
7-13-34	7/31/2013
7-13-35	7/31/2013
11-13-2	11/26/2013
12-17-4	12/31/2017

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STORAGE TANK AND INSTANTANEOUS DOMESTIC WATER HEATER

Measure Description

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

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

Instantaneous type units include gas instantaneous water heaters with a rated input capacity of greater than or equal to 50,000 and less than 200,000 BTU per hour and a manufacturer's specified storage capacity of less than 2 gallons, residential electric instantaneous water heaters with an input of 12 kilowatts or less and a manufacturer's specified storage capacity of less than 2 gallons and residential-duty commercial electric instantaneous water heaters with an input of greater than 12 kilowatts and less than or equal to 56.8 kilowatts and a manufacturer's specified storage capacity of 2 gallons or less.[170]

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

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Equipment Only)

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

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

Peak Coincident Demand Savings (Electric Equipment Only)

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

Annual Gas Energy Savings (Gas Equipment Only)

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[171]
ΔT_{main}	$T_{set} - T_{main}$	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	70 $=T_{set} - T_{amb}$	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)

[171] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.

Variable	Value	Notes
T_{set}	140	Water heater set point temperature (°F).[172]
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).[173]
$UEF_{baseline}$		Uniform Energy Factor of the baseline condition. See Baseline Efficiencies… section below for details regarding derivation of this input.
UEF_{ee}		Uniform Energy Factor of the energy efficient measure, from application
$UA_{baseline}$	7.85	Overall heat loss coefficient of the baseline condition (BTU/h-°F).[174]
UA_{ee}		Overall heat loss coefficient of the energy efficient measure (BTU/h-°F). For instantaneous water heaters, set UA_{ee} = 0. For storage type water heaters, set UA_{ee} = 5.4.[175]
CF	0.8	

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

City	Annual average outdoor temperature[177] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3

[172] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)

[173] 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.

[174] 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.

[175] Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory.

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

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

City	Annual average outdoor temperature[177] (°F)	T_{main} (°F)
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8[178].

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a minimally code compliant gas or electric storage or instantaneous type water heater (based on efficient conditions) with tank volume, input capacity and draw pattern equivalent to the efficient water heater.

$UEF_{baseline}$ shall be calculated as a function of qualifying equipment tank volume (v_t) for storage type water heaters or looked up for instantaneous water heaters per federal standards from the appropriate table (Residential Water Heaters or Residential-Duty Commercial Water Heaters) below, using the qualifying equipment type, capacity and draw pattern. Draw pattern can be established based on the efficient equipment First Hour Rating (FHR), rated in gallons, for storage type water heaters or Max Gallons per Minute (GPM), rated in gallons/minute, for instantaneous water heaters. See the First Hour Rating vs. Draw Pattern and Max GPM vs. Draw Pattern tables below for storage type and instantaneous water heaters, respectively. If FHR or Max GPM is unknown, a Medium draw pattern should be assumed for storage type water heaters with rated storage capacity ≤ 50 gallons and a High draw pattern should be assumed otherwise.[179]

Residential Water Heaters[180]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.3456 - (0.0020 \times v_t^*)$
		Low	$0.5982 - (0.0019 \times v_t)$
		Medium	$0.6483 - (0.0017 \times v_t)$
		High	$0.6920 - (0.0013 \times v_t)$
	> 55 gal and ≤ 100 gal	Very Small	$0.6470 - (0.0006 \times v_t)$
		Low	$0.7689 - (0.0005 \times v_t)$
		Medium	$0.7897 - (0.0004 \times v_t)$
		High	$0.8072 - (0.0003 \times v_t)$

178 *No source specified – update pending availability and review of applicable references.*
179 Based on review of typical usage bins for AHRI certified residential water heating equipment (https://www.ahridirectory.org/ahridirectory/pages/home.aspx)
180 10 CFR 430.32(d)

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x v_t)
		Low	0.9254 - (0.0003 x v_t)
		Medium	0.9307 - (0.0002 x v_t)
		High	0.9349 - (0.0001 x v_t)
	> 55 gal and ≤ 120 gal	Very Small	1.9236 - (0.0011 x v_t)
		Low	2.0440 - (0.0011 x v_t)
		Medium	2.1171 - (0.0011 x v_t)
		High	2.2418 - (0.0011 x v_t)
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*v_t = tank volume in gallons

Residential-Duty Commercial Water Heaters[181]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	$UEF_{baseline}$
Gas-Fired Storage Water Heater	> 75,000 BTU/h and ≤ 105,000 BTU/h and ≤ 120 gal	Very Small	0.2674 - (0.0009 x v_t^*)
		Low	0.5362 - (0.0012 x v_t)
		Medium	0.6002 - (0.0011 x v_t)
		High	0.6597 - (0.0009 x v_t)
Instantaneous Electric Water Heater	> 12 kW gal and ≤ 55 gal	Very Small	0.80
		Low	0.80
		Medium	0.80
		High	0.80

*v_t = tank volume in gallons

First Hour Rating vs. Draw Pattern (Storage Type Only)[182]

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

[181] 10 CFR 431.110(b)
[182] 10 CFR 429.17

Max GPM vs. Draw Pattern (Instantaneous Only)[183]

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a gas or electric storage or instantaneous type water heater as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

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[183] 10 CFR 429.17

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1	10/15/2010
6-13-1	6/30/2013
7-13-6	7/31/2013
11-13-2	11/26/2013
12-17-5	12/31/2017

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DOMESTIC HOT WATER – CONTROL

FAUCET – LOW-FLOW AERATOR

Measure Description

A low-flow faucet aerator is a water saving device with rated gallons per minute (gpm) less than maximum allowable flowrate as mandated by federal, state and regional code. New York City plumbing code and New York State construction code dictate a maximum flowrate of 2.2 gpm for sink faucets and 1.5 gpm for lavatory faucets. This is a retrofit direct install measure or a new installation in a residential application.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$H_2O_{savings}$	= Water savings
T	= Temperature (°F)
UEF	= Uniform energy factor
GPM	= Gallon per minute
$Flow_r$	= Flow rate restricted
8.33	= Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}	1.5	GPM for energy efficient measure, from application (Non-lavatory faucets)
	1.0	GPM for energy efficient measure, from application (Lavatory faucets)
$GPM_{baseline}$	2.2	GPM for baseline measure (Non-lavatory faucets)[184,185]
	1.5	GPM for baseline measure (Lavatory faucets)
$Flow_r$	0.75	Flow restriction factor of faucet aerator
minutes/use	0.5	Estimated duration of use (based on approximately 8.5 minutes of usage per faucet per day; assumes 26 minutes of faucet usage per household per day and 3 faucets per household)[186]
uses/day	17	Estimated number of uses per day (based on approximately 8.5 minutes of usage per faucet per day; assumes 26 minutes of faucet usage per household per day and 3 faucets per household)[187]
$H_2O_{savings}$	1,629	Calculated gallons of water saved per year based on installation of energy efficient measure (Non-lavatory faucets)
	1,163	Calculated gallons of water saved per year based on installation of energy efficient measure (Lavatory faucets)
T_{faucet}	80	The typical water temperature leaving the faucet in °F
T_{main}		Average inlet water temperature (see appending table) (°F)
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume high draw pattern)[188]

<u>Cold Water Inlet Temperature (T_{main})</u>

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[189] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[190] (°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

184 2017 NYS Uniform Code Supplement, Table P2903.2
185 2014 NYC Plumbing Code, Table 604.4
186 Water Research Foundation: Residential End Uses of Water, Version 2, April 2016
187 Ibid.
188 10 CFR 430.32(d)
189 Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
190 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

City	Annual average outdoor temperature[190] (°F)	T_{main} (°F)
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The Summary of Variables and Data Sources provides the baseline (standard) and low flow aerator water flows, related input assumptions, and the resulting water savings. Assumptions regarding average duration of use and number of uses per day are also presented. Uniform Energy Factor is determined for the assumed water heater system configurations cited per the table below (from Code of Federal Regulations 10 CFR 430.32(d)).

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Uniform Energy Factor
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.3456 - (0.0020 x V_t^*)
		Low	0.5982 - (0.0019 x V_t)
		Medium	0.6483 - (0.0017 x V_t)
		High	0.6920 - (0.0013 x V_t)
	> 55 gal and ≤ 100 gal	Very Small	0.6470 - (0.0006 x V_t)
		Low	0.7689 - (0.0005 x V_t)
		Medium	0.7897 - (0.0004 x V_t)
		High	0.8072 - (0.0003 x V_t)
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x V_t)
		Low	0.9254 - (0.0003 x V_t)
		Medium	0.9307 - (0.0002 x V_t)
		High	0.9349 - (0.0001 x V_t)
	> 55 gal and ≤ 100 gal	Very Small	1.9236 - (0.0011 x V_t)
		Low	2.0440 - (0.0011 x V_t)
		Medium	2.1171 - (0.0011 x V_t)
		High	2.2418 - (0.0011 x V_t)
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Uniform Energy Factor
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*V_t = Rated Storage Volume (gal)

Compliance Efficiency from which Incentives are Calculated

Compliance flow rates are specified in the Summary of Variables and Data Sources above.

Operating Hours

Operating hours are assumed at 365 days per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from:
   http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016
   Available from: http://www.waterrf.org/PublicReportLibrary/4309A.pdf
4. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-

idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
5. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
6. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
Available from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-13-5	6/30/2013
7-13-7	7/31/2013
6-17-2	6/30/2017

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Thermostatic Shower Restriction Valve

Measure Description

A thermostatic valve attached to a showerhead supply for reduction of domestic hot water flow and associated energy usage. The device restricts hot water flow through the showerhead by activating the trickle or stop flow mode when water reaches a temperature set point of 95°F, or slightly lower, depending on manufacturer. This measure is applicable to valves installed in residential applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
(ΔkWh/unit)	As defined in kWh Savings table below	Deemed annual electric energy savings for electric resistance storage tank water heater. Look up based on location and water usage rate (table below).
(Δtherm/unit)	As defined in Therm Savings table below	Deemed annual gas energy savings for natural gas storage tank water heater. Look up based on location and water usage rate (table below).
GPM_{ee}		Gallons per minute for energy efficient measure, from application
$Throttle_{fac}$	0.9	Used in LBNL study to adjust for occupant reduction in flow

Variable	Value	Notes
		rate[191]
Waste Time	1.58	Average value calculated from total water waste duration of five shower events (1 min., 35 secs.)[192]
Showers/day	2	Calculated from LBNL study based on assumption of 2.59 persons/household and 0.75 showers per day per capita[193]
T_{main}		Average inlet water temperature (°F) by location is shown below.
T_{shower}	105	Average temperature at showerhead; conservative assumption based on NYS plumbing code, EPA MFHR program and ASSE 1070-2014
UEF_{elec}	0.93	Uniform Energy Factor based on product class, size, input rating and draw pattern. Assumes electric storage water heater with 40-gal capacity at high draw.[194]
UEF_{gas}	0.64	Uniform Energy Factor based on product class, size, input rating and draw pattern. Assumes natural gas storage water heater with 40-gal capacity at high draw.[195]

kWh Savings (ΔkWh/unit)

Location	Flow Rate (GPM)				
	1	**1.25**	**1.5**	**1.75**	**2**
Albany	138	173	207	242	276
Binghamton	144	180	215	251	287
Buffalo	138	173	207	242	276
Massena	151	189	227	265	302
NYC	119	149	178	208	238
Poughkeepsie	134	168	201	235	268
Syracuse	138	173	207	242	276

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

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

191 LBNL: Potential Water and Energy Savings from Showerheads, March 2006
192 LBNL: Water and Energy Wasted During Residential Shower Events, September 2011
193 LBNL: Potential Water and Energy Savings from Showerheads, March 2006
194 10 CFR 430.32(d)
195 Ibid.

Therm Savings (Δtherm/unit)

Location	Flow Rate (GPM)				
	1	1.25	1.5	1.75	2
Albany	6.9	8.6	10.3	12.0	13.7
Binghamton	7.1	8.9	10.7	12.5	14.2
Buffalo	6.9	8.6	10.3	12.0	13.7
Massena	7.5	9.4	11.2	13.1	15.0
NYC	5.9	7.4	8.8	10.3	11.8
Poughkeepsie	6.6	8.3	10.0	11.6	13.3
Syracuse	6.9	8.6	10.3	12.0	13.7

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

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

Cold Water Inlet Temperature (T_{main})

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F.[196] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[197] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

If known and in compliance with applicable code, the actual flowrate of the showerhead should be used for determination of per unit energy savings from the tables above. Otherwise, a baseline of

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

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

2.0 gallons per minute shall be used for compliance in New York State (per 2017 NYS Uniform Code Supplement) and New York City, (per 2014 update to NYC Plumbing Code). Uniform Energy Factor is determined for the assumed water heater system configurations cited per the table below (from Code of Federal Regulations 10 CFR 430.32(d)).

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Uniform Energy Factor
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.3456 - (0.0020 x V_t*)
		Low	0.5982 - (0.0019 x V_t)
		Medium	0.6483 - (0.0017 x V_t)
		High	0.6920 - (0.0013 x V_t)
	> 55 gal and ≤ 100 gal	Very Small	0.6470 - (0.0006 x V_t)
		Low	0.7689 - (0.0005 x V_t)
		Medium	0.7897 - (0.0004 x V_t)
		High	0.8072 - (0.0003 x V_t)
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x V_t)
		Low	0.9254 - (0.0003 x V_t)
		Medium	0.9307 - (0.0002 x V_t)
		High	0.9349 - (0.0001 x V_t)
	> 55 gal and ≤ 100 gal	Very Small	1.9236 - (0.0011 x V_t)
		Low	2.0440 - (0.0011 x V_t)
		Medium	2.1171 - (0.0011 x V_t)
		High	2.2418 - (0.0011 x V_t)
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*V_t = Rated Storage Volume (gal)

Compliance Efficiency from which Incentives are Calculated

Compliance conditions require installation of a program qualified thermostatic shower restriction valve.

Operating Hours

Number of showers per day and duration of water waste are as listed above in Summary of Variables and Data Sources.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from: http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Lawrence Berkeley National Laboratory (LBNL): “Potential Water and Energy Savings from Showerheads”, March 2006
   Available from: http://www.map-testing.com/assets/files/Biermayer,%20P.%20(2006)%20Potential%20Water%20and%20Energy%20Savings%20from%20Showerheads.pdf
4. Lawrence Berkeley National Laboratory (LBNL): “Water and Energy Wasted During Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems”, September 2011
   Available from: https://efficiency.lbl.gov/sites/all/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_water_distribution_systems_lbnl-5115e.pdf
5. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
6. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

7. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
Available from:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf
8. Uniform Plumbing Code (UPC) certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a.

Record of Revision

Record of Revision Number	Issue Date
6-14-2	6/19/2014
6-17-3	6/30/2017

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SHOWERHEAD – LOW FLOW

Measure Description

A low flow showerhead is a water saving showerhead with rated gallons per minute (gpm) less than maximum allowable flowrate as mandated by federal, state and regional code. New York City plumbing code and New York State construction code dictate a maximum flowrate of 2.0 gpm for showerheads. This is a retrofit direct install measure or a new installation in a residential application.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$H_2O_{savings}$	= Water savings
T	= Temperature (°F)
UEF	= Uniform energy factor
GPM	= Gallon per minute
$Throttle_{fac}$	= Throttle factor
8.33	= Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		Gallons per minute for energy efficient measure, from application
$GPM_{baseline}$	2.0	Gallons per minute for baseline[198,199]
$Throttle_{fac}$	0.9	Used in LBNL study to adjust for occupant reduction in flow rate[200]
minutes/use	8.2	Average shower duration per LBNL study.[201]
uses/day	2	Calculated from LBNL study based on assumption of 2.59 persons/household and 0.75 showers per day per capita.[202]
T_{main}		Average inlet water temperature (˚F) by location is shown below.
T_{shower}	105	Average temperature at showerhead (˚F); conservative assumption based on 2014 NYS plumbing code, EPA MFHR program and ASSE 1070-2014
UEF	See UEF Table Below	Uniform Energy Factor based on product class, size, input rating and draw pattern (if unknown, assume high draw pattern)[203]

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

City	Annual average outdoor temperature[205] (°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

198 2017 NYS Uniform Code Supplement, Table P2903.2
199 2014 NYC Plumbing Code, Table 604.4
200 LBNL: Potential Water and Energy Savings from Showerheads, March 2006
201 Ibid.
202 Ibid.
203 10 CFR 430.32(d)
204 Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
205 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The Summary of Variables and Data Sources provides the baseline (stadard) water flow and related input assumptions. Assumptions regarding average duration of use and number of uses per day are also presented. Uniform Energy Factor is determined for the assumed water heater system configurations cited per the table below (from Code of Federal Regulations 10 CFR 430.32(d)).

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Uniform Energy Factor
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.3456 - (0.0020 x V_t^*)
		Low	0.5982 - (0.0019 x V_t)
		Medium	0.6483 - (0.0017 x V_t)
		High	0.6920 - (0.0013 x V_t)
	> 55 gal and ≤ 100 gal	Very Small	0.6470 - (0.0006 x V_t)
		Low	0.7689 - (0.0005 x V_t)
		Medium	0.7897 - (0.0004 x V_t)
		High	0.8072 - (0.0003 x V_t)
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x V_t)
		Low	0.9254 - (0.0003 x V_t)
		Medium	0.9307 - (0.0002 x V_t)
		High	0.9349 - (0.0001 x V_t)
	> 55 gal and ≤ 100 gal	Very Small	1.9236 - (0.0011 x V_t)
		Low	2.0440 - (0.0011 x V_t)
		Medium	2.1171 - (0.0011 x V_t)
		High	2.2418 - (0.0011 x V_t)
Instantaneous Gas-Fired Water Heater	< 2 gal and > 50,000 BTU/h	Very Small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

Compliance Efficiency from which Incentives are Calculated

Compliance flow rate is less than the specified baseline value (<2.0 gpm) or less than the more restrictive codes or guidelines of local governments, municipalities or entities which, for example, participate in the US EPA Water Sense® Partnership Program. [206]

Operating Hours

Assumed duration of shower and assumed number of showers per day as listed above in Summary of Variables and Data Sources.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from:
   http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Lawrence Berkeley National Laboratory (LBNL): "Potential Water and Energy Savings from Showerheads", March 2006
   Available from: http://www.map-testing.com/assets/files/Biermayer,%20P.%20(2006)%20Potential%20Water%20and%20Energy%20Savings%20from%20Showerheads.pdf
4. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
5. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals

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

Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
6. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
Available from:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf
7. EPA WaterSense® Partnership Program
Available from: https://www.epa.gov/watersense/partners-directory

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-13-4	6/30/2013
6-15-1	6/15/2015
6-17-4	6/30/2017

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DRAIN WATER HEAT RECOVERY

Measure Description

This measure covers the installation of drain water heat recovery systems on a main waste drain in residential 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 Peak Coincident Demand Savings

Annual Electric Energy Savings (For Electric Water Heating Equipment Only)

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

Peak Coincident Demand Savings (For Electric Water Heating Equipment Only)

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

Annual Gas Energy Savings (For Gas Water Heating Equipment Only)

$$\Delta therms = units \times \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \frac{1}{UEF} \times ESF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
GPD	= Gallons per day
ΔT_{main}	= Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	= Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
UEF	= Uniform energy factor
UA	= Overall heat loss coefficient (BTU/h-°F)
ESF	= Energy savings factor
CF	= Coincidence factor
365	= Days in one year
8.33	= Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[207]
ΔT_{main}	T_{set} - T_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	70 = T_{set} - T_{amb}	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
T_{set}	140	Water heater set point temperature (°F).[208]
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).[209]
UEF		Uniform Energy Factor of the baseline condition, from application, or use default based on Uniform Energy factor section below
UA	7.85	Overall heat loss coefficient of the baseline condition (BTU/h-°F).[210]
ESF	0.25	Oak Ridge National Laboratory. [211]
CF	0.8	

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

[207] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.

[208] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/etools/hospital/hazards/leg/leg.html)

[209] 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.

[210] 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.

[211] GFX Evaluation, Oak Ridge National Laboratory, August 2000, lower end of the energy savings range (25-30%)

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

City	Annual average outdoor temperature[213] (°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

Uniform Energy Factor

UEF shall be calculated as a function of existing equipment tank volume (v_t) with the appropriate equation, looked up based on existing equipment type, capacity and draw pattern. Draw pattern can be established based on the existing equipment First Hour Rating (FHR), rated in gallons; see the First Hour Rating vs. Draw Pattern table below. If FHR is unknown, a Medium draw pattern should be assumed for storage type water heaters with rated storage capacity ≤50 gallons and a High draw pattern should be assumed otherwise.[214]

Residential Water Heaters[215]

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	UEF
Gas-Fired Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	$0.3456 - (0.0020 \times v_t^*)$
		Low	$0.5982 - (0.0019 \times v_t)$
		Medium	$0.6483 - (0.0017 \times v_t)$
		High	$0.6920 - (0.0013 \times v_t)$
	> 55 gal and ≤ 100 gal	Very Small	$0.6470 - (0.0006 \times v_t)$
		Low	$0.7689 - (0.0005 \times v_t)$
		Medium	$0.7897 - (0.0004 \times v_t)$
		High	$0.8072 - (0.0003 \times v_t)$

*v_t = tank volume in gallons

213 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

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

215 10 CFR 430.32(d)

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	UEF
Electric Storage Water Heater	≥ 20 gal and ≤ 55 gal	Very Small	0.8808 - (0.0008 x v_t)
		Low	0.9254 - (0.0003 x v_t)
		Medium	0.9307 - (0.0002 x v_t)
		High	0.9349 - (0.0001 x v_t)
	> 55 gal and ≤ 120 gal	Very Small	1.9236 - (0.0011 x v_t)
		Low	2.0440 - (0.0011 x v_t)
		Medium	2.1171 - (0.0011 x v_t)
		High	2.2418 - (0.0011 x v_t)

*v_t = tank volume in gallons

Residential-Duty Commercial Water Heaters[216]

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

*v_t = tank volume in gallons

First Hour Rating vs. Draw Pattern[217]

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[218]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a storage type water heater without a DWHR system in a residential 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 residential application. DWHR units must have a minimum efficiency of 40% if

[216] 10 CFR 431.110(b)
[217] 10 CFR 429.17
[218] *No source specified – update pending availability and review of applicable references.*

installed for equal flow or a minimum efficiency of 52% if installed for unequal flow.[219] 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.[220]

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

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430.2 Definitions.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=78ea8c7c6bf5379d6e0fd2b41e335739&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12
2. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
3. 10 CFR 431.110 Energy conservation standards and their effective dates.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=a69096e892b13c204bbe6da3a92f8111&mc=true&node=se10.3.431_1110&rgn=div8
4. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016
   Available from: http://www.waterrf.org/PublicReportLibrary/4309A.pdf
5. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from: https://www.osha.gov/SLTC/etools/hospital/hazards/leg/leg.html
6. GFX Evaluation, Oak Ridge National Laboratory, August 2000
   Available from: http://gfxtechnology.com/Duluth-Triplex.pdf
7. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters

[219] NYSERDA NYStretch Code – Energy 2018, Section R403.5.4.3 Drain water heat recovery units
[220] ECCCNYS 2016, Section R403.5.4 Drain Water Recovery Units

Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e

8. 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters
   Available from:
   https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf
9. AHRI Directory of Certified Product Performance
   Available from: https://www.ahridirectory.org/ahridirectory/pages/home.aspx
10. Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
    Available from:
    http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=05D73BA6EF5ECCF71969D083FB317991?doi=10.1.1.515.6885&rep=rep1&type=pdf
11. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
    Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
12. 10 CFR 429.17 Water heaters.
    Available from: : https://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=10:3.0.1.4.17#se10.3.429_117
13. NYSERDA NYStretch Code – Energy 2018, Section 403.5.4.3 Drain Water Heat Recovery Unit
    Available from: https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Code-Training/NYStretch-Code-Energy-2018
14. ECCCNYS 2016, per IECC 2015; Section R403.5.4 Drain Water Heat Recovery Units
    Available from: https://codes.iccsafe.org/content/IECC2015NY-1/chapter-4-re-residential-energy-efficiency

Record of Revision

Record of Revision Number	Issue Date
12-18-7	12/28/2018

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

AIR CONDITIONER - CENTRAL (CAC)

Measure Description

This measure covers the installation of high-efficiency central air conditioners in residential applications. A central air conditioner is a product, other than a packaged terminal air conditioner, which is powered by single phase electric current, air cooled, rated below 65,000 BTU/h, not contained within the same cabinet as a furnace with rated capacity above 225,000 BTU/h, and is a cooling unit only. A central air conditioner may consist of a single-package unit or an outdoor unit and one or more indoor units, including multi-head mini-split systems.[221] The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local energy conservation code.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
EER	= Energy efficiency ratio under peak conditions
CF	= Coincidence factor

[221] 10 CFR 430.2

12 = (kBTU/h)/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application, default to average system size from applications if unknown
$SEER_{baseline}$		Lookup from Baseline Efficiencies table below based on product class and size.
$SEER_{ee}$		From application
$EFLH_{cooling}$		Lookup based on building type, vintage and location from Appendix G.
$EER_{baseline}$		Lookup from Baseline Efficiencies table below based on product class and size.
EER_{ee}		From application
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[222]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a central air conditioner as defined in the Measure Description section above, with rated SEER and EER per the table below. The SEER values listed in the table below reflect the minimum performance required by federal standards. Minimum EER requirements are not specified by federal standards for the state of New York, nor are they mandated by state or city code for residential equipment. For this equipment, baseline EER is established as follows[223]:

$$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$$

Resultant values from application of this equation are tabulated in the baseline efficiencies table below.

[222] 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 the Mid-Atlantic TRM Version 7.0 published May 2017 and 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.

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

Product Class	Seasonal Energy Efficiency Ratio (SEER)[224]	Energy Efficiency Ratio (EER)
Split System – Air Conditioner (<45 kBTU/h)	13.0	11.2
Split System – Air Conditioner (≥45 and <65 kBTU/h)	13.0	11.2
Single Package – Air Conditioner	14.0	11.8

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a central air conditioner as defined in the Measure Description section above meeting minimum performance requirements dictated by program guidelines.

Operating Hours

Cooling EFLH data by location, building type and vintage are tabulated in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Minor heating interactions are expected with efficient furnace fans utilized in most high efficiency air conditioners. These impacts are expected to be negligible and have not been addressed in the prescribed methodology at this time.

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430.2 Definitions.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=5caa706c36f6a4bc5850185c41f2175f&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12
2. BG&E, Development of Residential Load Profile for Central Air Conditioners and Heat Pumps, via Mid-Atlantic Technical Reference Manual Version 7.0, May 2017 (accessed October 26, 2017)
   Available from:
   http://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V7_FINAL.pdf
3. M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011
   Available from: https://www.sciencedirect.com/science/article/pii/S1040619011001941

[224] 10 CFR 430.32 (c)(1)

4. Building America House Simulation Protocols, Robert Hendron and Cheryn Engebrecht, National Renewable Energy Laboratory, October 2010
Available from:
https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/house_simulation_revised.pdf
5. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
12-17-6	12/31/2017

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AIR CONDITIONER - ROOM (RAC)

Measure Description

This measure covers the installation of high-efficiency room air conditioners in residential applications. A room air conditioner is a consumer product, other than a packaged terminal air conditioner, which is powered by a single phase electric current and is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilation and heating.[225] The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local energy conservation code. This measure is not applicable to central air conditioner systems.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
(BTU/h)/unit = British Thermal Units per hour of air conditioning per unit
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
CEER = Combined Energy Efficiency Ratio
EFLH = Equivalent full-load hours
CF = Coincidence factor
1,000 = Conversion factor, one kW equals 1,000 Watts

[225] 10 CFR 430.2

Summary of Variables and Data Sources

Variable	Value	Notes
(BTU/h)/unit		From application
$CEER_{baseline}$		Lookup from Baseline Efficiencies section below based on equipment type and capacity.
$CEER_{ee}$		From application
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup from Operating Hours section below based on location.
CF	0.3	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.3.[226] The average Seasonal CF based on 2007 weather data used for this measure aligns with results of a sampling study conducted in Con Edison territory, citing a CF = 0.31.[227]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a room air conditioner as defined in the Measure Description section above with type and capacity equivalent to the efficient case and rated CEER per the table below. The CEER values listed in the table below reflect the minimum performance required by federal standards.[228]

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a room air conditioner as defined in the Measure Description section above meeting minimum performance requirements dictated by program guidelines.

[226] RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008, p. iv (based on average Seasonal CF for all load zones using 2007 weather data)
[227] Northeast Energy Efficiency Partnerships, Loadshape Report and Catalogue
[228] 10 CFR 430.32(b)

Operating Hours

Cooling equivalent full load hours for residential room air conditioners shall be established based on location per the table below. $EFLH_{cooling}$ values below were determined by calculating the ratio of RAC cooling EFLH in Albany[229] to average cooling EFLH in Albany per Appendix G and applying it to the average EFLH for each city. EFLH was averaged from Appendix G over vintage and building type for each city.

City	$EFLH_{cooling}$
Albany	224
Binghamton	171
Buffalo	219
Massena	187
NYC	364
Poughkeepsie	282
Syracuse	226

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430.2 Definitions.
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=ccdb0d0ac67a5eab52718c408f0739a1&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_12
2. RLW Analytics, Coincidence Factor Study: Residential Room Air Conditioners, June 2008
   Available from: https://library.cee1.org/system/files/library/8791/CEE_Eval_FinalReportCoincidenceFactorStudyResidentialRoomAirConditioners2008_23Jun2008.pdf
3. Northeast Energy Efficiency Partnerships, Loadshape Report and Catalogue June 2016
   Available from: http://www.neep.org/loadshape-report-and-catalogue

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

4. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
3-18-2	3/29/2018

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REFRIGERANT CHARGE CORRECTION & TUNE UP – AIR CONDITIONER AND HEAT PUMP

Measure Description

This measure estimates savings associated with refrigerant charge correction for unitary and split system air conditioners and heat pumps in single and multi-family residential applications. In order to be eligible for energy savings, the scope of work performed must include manufacturer recommended AC tune-up procedures including but not limited to the cleaning of the condenser coils.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For Units with Cooling Capacity < 65,000 BTU/h

$$\Delta kWh = units \times \left\{\left[tons/unit \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling}\right] + \left[(kBTU/h)_{out}/unit \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}\right]\right\}$$

For Units with Cooling Capacity ≥ 65,000 BTU/h

$$\Delta kWh = units \times \left\{\left[tons/unit \times \left(\frac{12}{IEER_{baseline}} - \frac{12}{IEER_{ee}}\right) \times EFLH_{cooling}\right] + \left[\frac{(kBTU/h)_{out}/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right]\right\}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)

$(kBTU/h)_{out}/unit$= Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
$_{ee}$ = Energy efficient condition or measure
$_{baseline}$ = Baseline condition or measure
SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
IEER = Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions (used only for units with cooing capacity ≥ 65,000BTU/h)
EER = Energy efficiency ratio under peak conditions, measurement of cooling capacity for a unit (in BTU/h) / electrical energy used (watts) (at AHRI standard rating conditions)
HSPF = Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP = Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$EFLH_{cooling}$ = Equivalent full-load cooling hours
$EFLH_{heating}$ = Equivalent full-load heating hours
CF = Coincidence factor
12 = (kBTU/h)/ton of air conditioning capacity
3.412 = Conversion factor, one watt-hour equals 3.412 BTU

Summary of Variables and Data Sources

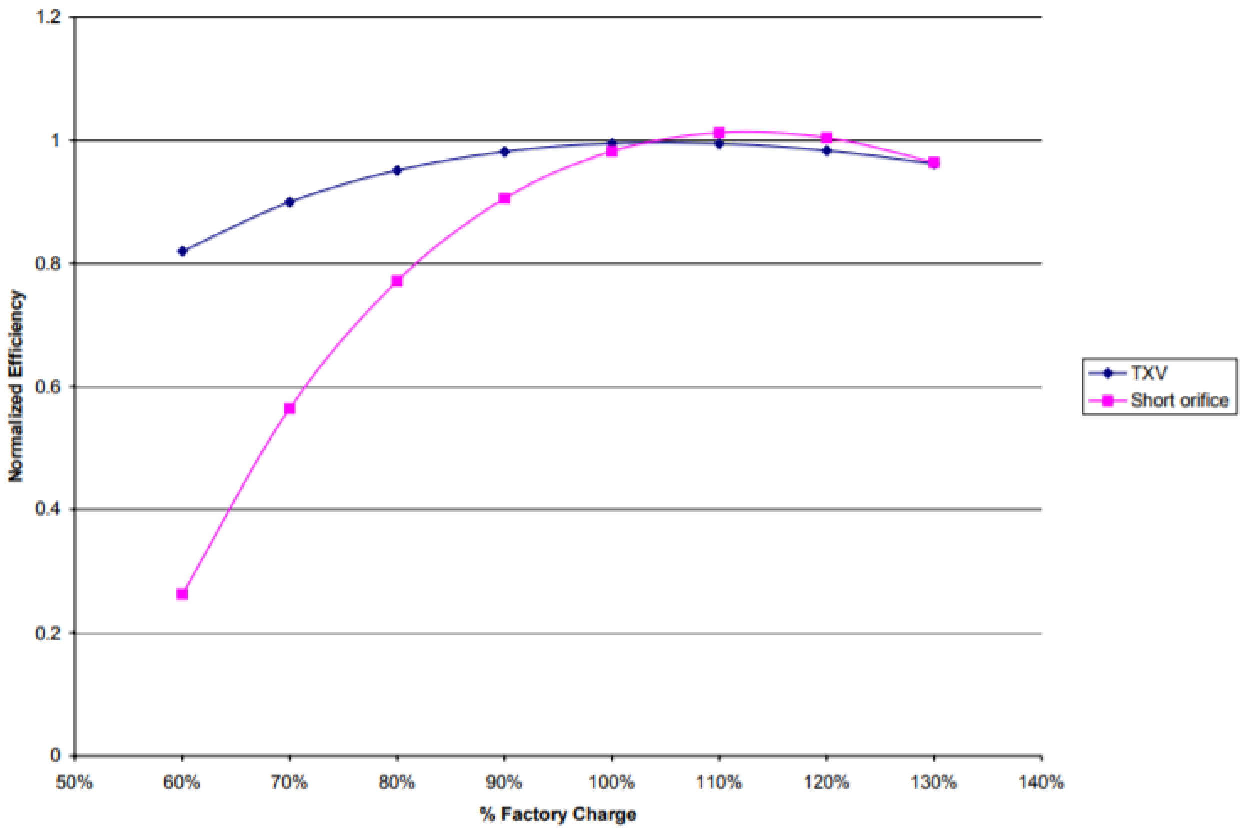
Variable	Value	Notes
tons/unit		From application.
$kBTU/h_{out}$		From application.
$SEER_{ee}$		Actual equipment nameplate SEER.
$SEER_{baseline}$		Actual equipment nameplate SEER, derated in accordance with the Baseline Efficiency section below.
$IEER_{ee}$		Actual equipment nameplate IEER.
$IEER_{baseline}$		Actual equipment nameplate IEER, derated in accordance with the Baseline Efficiency section below.
EER_{ee}		Actual equipment nameplate EER.
$EER_{baseline}$		Actual equipment nameplate EER, derated in accordance with the Baseline Efficiency section below.
$HSPF_{ee}$		Actual equipment nameplate HSPF.
$HSPF_{baseline}$		Actual equipment nameplate HSPF, derated in accordance with the Baseline Efficiency section below.
COP_{ee}		Actual equipment nameplate COP.
$COP_{baseline}$		Actual equipment nameplate COP, derated in accordance with the Baseline Efficiency section below.
$EFLH_{cooling}$		Look up based on building type, vintage and location in Appendix G.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[230]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is equivalent to the existing condition with efficiency ratings taken from the actual equipment nameplate, derated to account for under or overcharging. The efficiency improvement resulting from refrigerant charge adjustment is dependent upon the discrepancy between the actual equipment charge before the adjustment was performed and the manufacturer's specification. The efficiency adjustment factor as a function of charge adjustment is taken from the figure or table below.[231] Note the efficiency change depends on the type of expansion valve. Use the curve or column labeled "TXV" for units with thermal expansion valves; otherwise use the curve or column labeled "Short orifice".



[230] 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.

[231] Efficiency as a function of charge adjustment from Small HVAC System Design Guide, New Buildings Institute, 2003

% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)	% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)
60%	0.26	0.82	96%	0.96	0.99
62%	0.32	0.84	98%	0.97	0.99
64%	0.39	0.85	100%	0.98	1.00
66%	0.45	0.87	102%	0.99	1.00
68%	0.51	0.89	104%	1.00	1.00
70%	0.56	0.90	106%	1.00	1.00
72%	0.61	0.91	108%	1.00	1.00
74%	0.66	0.92	110%	1.00	1.00
76%	0.70	0.93	112%	1.00	0.99
78%	0.73	0.94	114%	1.00	0.99
80%	0.77	0.95	116%	1.00	0.99
82%	0.80	0.96	118%	1.00	0.99
84%	0.83	0.97	120%	1.00	0.99
86%	0.86	0.97	122%	1.00	0.98
88%	0.88	0.98	124%	0.99	0.98
90%	0.91	0.98	126%	0.98	0.97
92%	0.92	0.99	128%	0.97	0.97
94%	0.94	0.99	130%	0.96	0.96

If the equipment is a multi-circuit system, the overall efficiency adjustment shall be calculated as the sum of each circuit's derating factor multiplied by its percentage of the total system capacity. For example, the equation for $EER_{baseline}$ is shown below:

$$EER_{baseline} = EER_{ee} \times \sum_{n} (Cap_n \times Fderate_n)$$

where:

n = Each circuit
Cap = Fraction of total capacity
Fderate = Derating factor, normalized efficiency from figure/table above

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential air-cooled unitary or split system air conditioner or heat pump that has undergone a tune up involving a refrigerant charge correction. SEER, IEER, EER, HSPF, and COP values are taken from application as reported on the equipment nameplate or manufacturer specifications.

Operating Hours

For central air conditioners and heat pumps, look up EFLH data by location, building type and vintage from Appendix G. The oversizing assumptions embedded in the Appendix G data are appropriate for equipment sized to meet the peak-cooling load for central air conditioners and air source heat pumps.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. Small HVAC System Design Guide, New Buildings Institute, White Salmon, WA for the California Energy Commission.
   Available from: http://www.energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-12.PDF

Record of Revision

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1	10/15/2010
6-18-3	6/26/2018

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BLOWER FAN – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR FOR HVAC DISTRIBUTION

Measure Description

This measure covers the retrofit of direct-drive Permanent Split Capacitor (PSC) motors with the installation of Electronically Commutated (EC) motors on gas furnace distribution system supply fans in residential applications. Energy savings are realized through reductions in fan power due to improved motor efficiency.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of motors installed under the program
(ΔkWh/unit) = Annual electric savings per motor installed
(ΔkW/unit) = Electric demand savings per motor installed
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
(ΔkWh/unit)		Lookup based on location and HVAC system type in table below.[232]
(ΔkW/unit)	Central AC: 0.117 No Central AC: 0	Derived from Focus on Energy evaluation.[233]
CF	0.68	

[232] Cadmus Group, Focus on Energy Evaluated Deemed Savings Changes, November 2014
[233] Ibid.

The deemed annual electric energy savings are determined for each New York location by scaling the energy savings derived from the evaluation of a 2014 Wisconsin ECM metering study using heating degree days and cooling degree days for each location.[234] The Wisconsin study metered furnaces in 67 homes in Wisconsin in 2012 and 2013.

The total energy savings for each New York location are provided in the "Total" columns below. The energy savings are determined by summing the savings attributed to each furnace mode: circulation, heating and cooling. Homes with a central A/C receive the savings in the "Total (with Central A/C)" column. Homes without a central A/C receive the savings in the "Total (without Central A/C)": these savings exclude the "Cooling Mode" savings. The HDD and CDD values are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using base 65° F.[235]

City	Annual Energy Saved (ΔkWh/unit)					HDD	CDD
	Total (with Central A/C)	Total (without Central A/C)	Circulation Mode	Heating Mode	Cooling Mode		
Albany	404	333	211	122	71	6,680	597
Binghamton	388	342	211	131	46	7,193	382
Buffalo	397	332	211	121	65	6,617	544
Massena	404	361	211	150	43	8,196	363
NYC	435	296	211	85	139	4,671	1,160
Poughkeepsie	404	324	211	113	80	6,210	671
Syracuse	401	333	211	122	68	6,651	570

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.68.[236]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a residential furnace (with or without central AC) with a direct-drive PSC distribution system blower motor.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential furnace (with or without central AC) with an EC distribution system blower motor.

[234] The percent difference in HDD is applied to the Heating Mode column kWh savings and the percent difference in the CDD is applied to the Cooling Mode column kWh savings.
[235] Annual/Seasonal Normals taken from http://www.ncdc.noaa.gov/cdo-web/datatools/normals
[236] Cadmus Group, Focus on Energy Evaluated Deemed Savings Changes, November 2014

Operating Hours

While deemed savings are associated with operating hours, savings values are established based on a comparison of heating and cooling degree days for various locations in NY state and Wisconsin. As such, operating hours are not directly applied in the methodology prescribed for this measure, though they are embedded in the derivation of deemed savings. Circulation mode savings and by association, operating hours, are assumed to align with findings of the Wisconsin ECM metering study. Thus, savings associated with circulation-only mode are equivalent across all climate zones.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Cadmus Group, Inc., Focus on Energy Evaluated Deemed Savings Changes, prepared for The Public Service Commission of Wisconsin, November 14, 2014
   Available from:
   https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
2. Cadmus Group, Inc., June 4, 2014 ECM Metering Results Memo. Delivered to Carol Stemrich, PSC of Wisconsin.
3. NOAA National Centers for Environmental Information – 1981-2010 Normals.
   Available from: http://www.ncdc.noaa.gov/cdo-web/datatools/normals

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0	10/15/2010
1	3/31/2016
6-16-2	6/30/2016
12-17-7	12/31/2017

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CIRCULATOR PUMP – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR FOR HYDRONIC DISTRIBUTION

Measure Description

This measure covers the retrofit of standard efficiency permanent split capacitor (PSC) motors with electronically commutated (EC) motors in hydronic distribution circulators in residential heating and cooling systems. A circulator pump is a specific type of pump used to circulate liquids in a closed distribution system. They are commonly found circulating water in a hydronic heating or cooling system.

Circulator pumps used in hydronic systems are usually electrically powered centrifugal pumps. When used in homes, they are often small, sealed, and rated at a fraction of a horsepower. The sealed units used in home applications often have the motor rotor, pump impeller, and support bearings combined and sealed within the water circuit. This avoids one of the principal challenges faced by the larger, two-part pumps: maintaining a water-tight seal at the point where the pump drive shaft enters the pump body.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hp \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) \times LF \times 0.746\ (kW/hp) \times hrs$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
hp	= Efficient circulator motor horsepower
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
Eff	= Efficiency
LF	= Load factor
hrs	= Annual hours of operation
CF	= Coincidence factor
0.746	= Conversion factor (kW/hp), 746 watts equals one electric horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application.
$Eff_{baseline}$	0.60	Baseline PSC motor efficiency[237]
Eff_{ee}	0.80	Efficient EC motor efficiency[238]
LF	0.9	Assumed value to reflect that motors do not typically run at 100% of rated power.
hrs	Heating: 3,504 Cooling: 2,208	Heating based on Assessment of New Energy Efficienct Circulator Pump Technology. [239] Cooling assumes three months (92 days) of 24 hour operation.
CF	Heating: N/A Cooling: 0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor for heating is N/A.
The prescribed value for the coincidence factor for cooling is 0.8.[240]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a hydronic circulator pump operating with a standard permanent split-capacitor (PSC) motor in a residential heating and/or cooling system.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a hydronic circulator pump operating with a high efficiency EC motor in a residential heating and/or cooling system. High efficiency circulators may include better impeller design that will further increase kWh savings, but these benefits are not considered in the prescribed savings estimation methodology.

Operating Hours

Annual circulator operating hours in a hydronic heating system are assumed to be 3,504, based on assumed 40% utilization of circulator pump. Savings will be less if the circulator cycles on and off with calls for heating.

Annual circulator operating hours in a hydronic cooling system are assumed to be 2,208, reflective of utilization of cooling systems for three months out of the year.

[237] US DOE, Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment, Table 2.1 Summary of Single-Phase AC Induction Motor Characteristics - Efficiency of the baseline condition is taken as the average full load efficiency rating range for a PSC motor.
[238] ACHR News, Comparing Motor Technologies, December 2009
[239] Assessment of New Energy Efficient Circulator Pump Technology, pg 4-3. Assumed circulator pump is utilized 40% of the year (0.40*8,760 = 3,504).
[240] *No source specified – update pending availability and review of applicable references.*

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Higher efficiency circulators may lead to increased gas consumption. Reduction in waste heat from increased efficiency in motors results in additional heating requirement. These effects are not quantified in this methodology.

Ancillary Electric Savings Impacts

Higher efficiency circulators may lead to reduced electric consumption. Reduction in waste heat from increased efficiency in motors results in decreased cooling requirement. These effects are not quantified in this methodology.

References

1. Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment, Building Technologies Office, US Department of Energy. December 2013.
   Available from:
   https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf
2. ACHR News, Comparing Motor Technologies, December 2009
   Available from: https://www.achrnews.com/articles/112674-comparing-motor-technologies
3. Assessment of New Energy Efficient Circulator Pump Technology, Electric Power Research Institute, November 2010
   Available from:
   https://publicdownload.epri.com/PublicDownload.svc/product=000000000001020132/type=Product

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0	10/15/2010
6-18-4	6/26/2018

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Duct Sealing and Insulation

Measure Description

This measure covers the installation of sealing and insulation of the space heating and air conditioning duct distribution system in the unconditioned spaces of single-family and multi-family homes. Duct sealing and insulation reduces air and thermal leakage into unconditioned and outdoor spaces, improving system efficiency. Sealing and insulation installed under this measure shall meet or exceed all applicable construction code requirements. This measure is only applicable in existing buildings. Only ductwork located in unconditioned spaces is eligible for savings.

This measure shall be implemented with the assistance of a duct-blaster test on the distribution system pre and post-implementation. A duct blaster test, similar in concept to a whole-house blower door test, is turned on to pressurize the duct system to 25 Pascal's (a pressure which represents typical operating pressures for forced-air systems). The airflow through the duct blaster fan (which is displayed in cfm on the duct blaster's manometer) equals the flow escaping through leaks in the duct system. The results are reported as "cfm @ 25 Pascal's".

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For AC and HP Units with Capacity <65,000 BTU/h

$$\Delta kWh = \frac{l_{duct,uncond}}{l_{duct}} \times \left\{\left[tons \times \frac{12}{SEER} \times EFLH_{cooling} \times \left(1 - \frac{Eff_{dist,cooling,baseline}}{Eff_{dist,cooling,ee}}\right) \times \left(1 - TRF_{cooling}\right)\right] + \left[kBTU/h_{out} \times \frac{1}{HSPF} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times \left(1 - TRF_{heating}\right)\right]\right\}$$

For AC and HP Units with Capacity ≥65,000 BTU/h

$$\Delta kWh = \frac{l_{duct,uncond}}{l_{duct}} \times \left\{\left[tons \times \frac{12}{IEER} \times EFLH_{cooling} \times \left(1 - \frac{Eff_{dist,cooling,baseline}}{Eff_{dist,cooling,ee}}\right) \times \left(1 - TRF_{cooling}\right)\right] + \left[\frac{kBTU/h_{out}}{3.412} \times \frac{1}{COP} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times \left(1 - TRF_{heating}\right)\right]\right\}$$

For Electric Furnaces

$$\Delta kWh = \frac{l_{duct,uncond}}{l_{duct}} \times kW_{in} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times (1 - TRF_{heating})$$

Peak Coincident Demand Savings

For AC and HP Units

$$\Delta kW = \frac{l_{duct,uncond}}{l_{duct}} \times tons/unit \times \frac{12}{EER} \times \left(1 - \frac{Eff_{dist,cooling,baseline}}{Eff_{dist,cooling,ee}}\right) \times (1 - TRF_{cooling}) \times CF$$

Annual Gas Energy Savings

For Gas Furnaces with Capacity < 225,000 BTU/h

$$\Delta therms = \frac{l_{duct,uncond}}{l_{duct}} \times \frac{kBTU/h_{in}}{100} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times (1 - TRF_{heating})$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
tons	= Output cooling capacity in tons (at AHRI standard rating conditions)
$kBTU/h_{out}$	= Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
kW_{in}	= Input heating capacity in kW
$kBTU/h_{in}$	= Input heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
$l_{duct,uncond}$	= Length of ductwork in each unconditioned space
l_{duct}	= Total length of ductwork
TRF	= Thermal Regain Factor
SEER	= Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling in BTU, divided by the total electric energy input during the same period in watt-hours
IEER	= Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions
EER	= Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTU/h divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
HSPF	= Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
EFLH	= Equivalent full-load hours
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
Eff_{dist}	= Distribution system efficiency
CF	= Coincidence factor
12	= (kBTU/h)/ton of air conditioning capacity

3.412 = Conversion factor, one watt-hour equals 3.412 BTU
100 = Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application.
$kBTU/h_{out}$		From application.
kW_{in}		From application.
$kBTU/h_{in}$		From application.
$L_{duct, uncond}$		From application.
L_{duct}		From application.
$TRF_{cooling}$		See table in the Thermal Regain Factor section below.
$TRF_{heating}$		See table in the Thermal Regain Factor section below.
SEER		Existing equipment nameplate SEER.
IEER		Existing equipment nameplate IEER.
EER		Existing equipment nameplate EER.
HSPF		Existing equipment nameplate HSPF.
COP		Existing equipment nameplate COP.
$EFLH_{heating}$		Look up based on building type, vintage and location from Appendix G.
$EFLH_{cooling}$		Look up based on building type, vintage and location from Appendix G.
$Eff_{dist,cooling,baseline}$		Look up in Appendix H for uninsulated duct system based on building type, location and duct leakage in cooling mode.
$Eff_{dist,heating,baseline}$		Look up in Appendix H for uninsulated duct system based on building type, location and duct leakage in heating mode.
$Eff_{dist,cooling,ee}$		Look up in Appendix H for R-6 insulated duct system based on building type, location and duct leakage in cooling mode.
$Eff_{dist,heating,ee}$		Look up in Appendix H for R-6 insulated duct system based on building type, location and duct leakage in cooling mode.
CF	0.69	

Thermal Regain Factor[241]
Some energy loss from poorly sealed and insulated ducts can be regained through conduction back into conditioned spaces. The table below lists default thermal regain factors depending on the location of the ductwork. Ductwork in garages, crawl spaces and under slab should be treated as Unconditioned Basement for Appendix H lookup.

Duct Location	$TRF_{cooling}$	$TRF_{heating}$
Attic	0.10	0.10
Garage	0.10	0.10
Crawl space, unvented, uninsulated	0.60	0.60
Crawl Space, Unvented, Insulated Building Floor and Crawl Space walls	0.60	0.30

241 Home Energy Saver & Score: Engineering Documentation, Thermal Distribution Efficiency

Duct Location	$TRF_{cooling}$	$TRF_{heating}$
Crawl Space, Unvented, Insulated Floor Only	0.30	0.30
Crawl Space, Vented, Uninsulated	0.60	0.55
Crawl Space, Insulated Building Floor and Crawl Space Walls	0.63	0.60
Crawl Space, Vented, Insulated Floor Only	0.30	0.30
Basement, Uninsulated	0.50	0.50
Basement, Insulated Walls	0.60	0.60
Under-slab	0.20	0.20

For duct systems in multiple unconditioned spaces, evaluate the ductwork in each space separately and sum together to calculate the total energy savings. For each equation, use the length of the insulated ductwork in each specific unconditioned space.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[242]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a ducted HVAC system with insufficient sealing and insulation that has undergone duct-blaster testing. Look up baseline uninsulated distribution system efficiency from Appendix H based on building type, location and duct total leakage.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a sealed and insulated duct system in a retrofit application that has undergone post-implementation duct-blaster testing. Supply and return ducts shall be insulated to a minimum of R-8 where 3 inches in diameter or greater and R-6 where less than 3 inches in diameter. Total leakage shall be less than or equal to 4 cubic feet per minute per 100 ft^2 of conditioned floor area.[243]

Look up compliance distribution system efficiency from Appendix H based on building type, location and duct total leakage from duct blaster test. Models for HVAC distribution efficiency with R-8 insulation are currently under development; values associated with R-6 shall be used until R-8 data is available.

Operating Hours

Cooling and heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the

[242] 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 the Mid-Atlantic TRM Version 7.0 published May 2017 and 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.
[243] ECCCNYS 2016 & NYCECC 2016, R403.3.1 & R403.3.4.

prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. Home Energy Saver & Score: Engineering Documentation, Thermal Distribution Efficiency
   Available from: http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/heating-and-cooling-calculation/thermal-distribution-efficiency/thermal-distribution-efficiency
3. ECCCNYS 2016, per IECC 2015; R403.3.1: Insulation (Prescriptive) & R403.3.4: Duct Leakage (Prescriptive)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-re-residential-energy-efficiency
4. NYCECC 2016; R403.3.1: Insulation (Prescriptive) & R403.3.4: Duct Leakage (Prescriptive)
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHR4.pdf&section=energy_code_2016

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1	10/15/2010
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Furnace and Boiler

Measure Description

This measure includes high efficiency gas fired furnaces, boilers, and unit heaters in low-rise residential building applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{unit} \times \left(\frac{Eff_{ee}}{Eff_{baseline}} - 1\right) \times \frac{EFLH_{heating}}{100}$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta therms$ = Annual gas energy savings
units = Number of measures installed under the program
$kBTU/h_{in}$ = Fuel Input Rating
Eff_{ee} = Efficiency of energy efficient condition or measure
$Eff_{baseline}$ = Efficiency of baseline condition or measure
$EFLH_{heating}$ = Heating equivalent full-load hours
100 = Conversion factor (100 kBTU/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTU/h_{in}$		Nominal heating input capacity is the nameplate input rating of the unit in kBTU/h, from application.
$Eff_{baseline}$	See Baseline Efficiency	Baseline established by applicable energy conservation code, climatic zone, equipment type and size, fuel source, as well as system configuration.
Eff_{ee}	See Compliance Efficiency	From application; use metrics consistent with baseline $EFLH_{heating}$
$EFLH_{heating}$		Lookup based on building type and location, Appendix G

Efficiency is expressed as the ratio between the fuel input relative to the output. The efficiency of furnaces, boilers and unit heaters is customarily evaluated on the basis of one or more of three standards, and are referred to as Thermal Efficiency (E_t), Combustion Efficiency, (E_c) or Annual Fuel Utilization Efficiency (AFUE).

Presently, the AFUE value is only applicable to smaller units. For larger units, use thermal and combustion efficiencies referenced on manufacturer's nameplate data in accordance with nationally recognized standards and testing agencies.

Coincidence Factor (CF)

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

Baseline Efficiencies From Which Savings are Calculated

The baseline efficiency for residential furnaces, boilers, and unit heaters ($\eta_{baseline}$) is defined by the Code of Federal Regulations and subsequently adopted by the Energy Conservation Code of New York State[244], and the New York City Energy Conservation Code[245] as shown below.

Systems Serving Single-Family Homes or Single Units[246]

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

[244] ECCCNYS 2016, Table C403.2.3(4) and Table C403.2.3(5)
[245] NYCECC 2016; Table C403.2.3(4) and Table C403.2.3(5)
[246] 10 CFR 430.32(e)

Systems Serving Multiple Dwelling Units

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.78 AFUE or 0.80 Et	0.78 AFUE or 80 Et
	≥ 225 kBTU/h	0.80 Et	80 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 Ec	80 Ec
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.80 AFUE	80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 Et	80 Et
	> 2,500 kBTU/h	0.82 Ec	82 Ec
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.75 AFUE	75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 Et	79 Et
	> 2,500 kBTU/h	0.79 Et	79 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.75 AFUE	75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 Et	77 Et
	> 2,500 kBTU/h	0.77 Et	77 Et

Compliance Efficiencies from Which Incentives are Calculated

Equipment Type	Size Range	Minimum Compliance Efficiency for Climate Zones 4, 5 and 6	Minimum Compliance Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.92 AFUE	0.92 AFUE
	≥ 225 kBTU/h	0.90 Et	0.90 Et
Warm Air Unit Heaters, Gas Fired	All Capacities	0.83 Ec	0.83 Ec
Boiler, Non-Condensing, Hot Water, Gas Fired	< 300 kBTU/h	0.85 AFUE	0.85 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.85 Et	0.85 Et
	> 2,500 kBTU/h	0.88 Ec	0.88 Ec
Boiler, Condensing, Hot Water, Gas Fired	< 300 kBTU/h	0.90 AFUE	0.90 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.90 Et	0.90 Et
	> 2,500 kBTU/h	0.93 Ec	0.93 Ec
Boiler, Steam, Gas	< 300 kBTU/h	0.82 AFUE	0.82 AFUE

Equipment Type	Size Range	Minimum Compliance Efficiency for Climate Zones 4, 5 and 6	Minimum Compliance Efficiency for NYC Boroughs in Climate Zone 4
Fired, All Except Natural Draft	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et	0.82 Et
	> 2,500 kBTU/h	0.82 Et	0.82 Et
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.82 AFUE	0.82 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.82 Et	0.82 Et
	> 2,500 kBTU/h	0.82 Et	0.82 Et

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

High efficiency furnaces may be packaged with high efficiency cooling equipment and/or electronically commutated blower motors, which may provide electricity savings. Draft fans, when present, will increase electricity consumption.

References

1. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
2. ECCCNYS 2016, per IECC 2015; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers.
Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency

3. NYCECC 2016; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
4. 2015 ASHRAE Handbook – HVAC Applications, Table 4: Comparison of Service Life Estimates

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-32	7/31/2013
8-13-1	8/31/2013
6-15-5	6/1/2015
1-16-2	12/31/2015
6-17-5	6/30/2017

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FURNACE TUNE-UP

Measure Description

This measure covers tune-up of residential natural gas furnaces to improve seasonal heating efficiency. A tune-up involves the inspection, cleaning, and or adjustment of furnace and appurtenances per manufacturer's recommendations. This measure addresses tune up benefits associated with heating performance only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \Delta therms \times (\Delta kWh/\Delta therms)$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{unit} \times \frac{EFLH_{heating}}{100} \times ESF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$kBTU/h_{in}$	= Annual gas input rating
EFLH	= Equivalent full-load hours
ESF	= Energy savings factor
(ΔkWh/Δtherms)	= Annual electric energy savings per unit annual gas energy savings
100	= Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{in}$		From application.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
ESF	0.05	The energy savings factor for furnace tune-ups is used to estimate the annual heating energy savings.[247]

[247] Energy savings on the order of 2% - 5% were realized from a boiler tune-up program in the Pacific Northwest. Building Tune-Up and Operations Program Evaluation. Washington State University Energy Program, p. 5.

Variable	Value	Notes
(ΔkWh/Δtherms)	0.5	Savings resultant from reduced fan run time due to improved efficiency and cycling of furnace.[248]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a residential gas-fired furnace that has not received a tune-up in 5 years or more.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential gas-fired furnace that has undergone a tune-up in accordance with the manufacturer's recommendations.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for single and multi-family buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Dethman and Kunkle, Building Tune-Up and Operations Program Evaluation. Washington State University Energy Program, 2007.
   Available from: https://library.cee1.org/system/files/library/1808/990.pdf
2. Electricity Savings from Variable-Speed Furnaces in Cold Climates, Scott Pigg, Energy Center of Wisconsin & Tom Talerico, Glacier Consulting Group
   Available from:
   https://aceee.org/files/proceedings/2004/data/papers/SS04_Panel1_Paper23.pdf

[248] Electricity Savings from Variable-Speed Furnaces in Cold Climates, Scott Pigg, Energy Center of Wisconsin & Tom Talerico, Glacier Consulting Group

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
3-18-13	3/29/2018

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Boiler Tune-Up

Measure Description

This measure covers tune-up of residential natural gas space heating boilers to improve seasonal heating efficiency. A tune-up involves the inspection, cleaning, and/or adjustment of boiler and appurtenances per manufacturer's recommendations. This measure addresses tune-up benefits associated with heating performance in single family or low-rise multifamily buildings only. For boiler tune-up in high-rise multifamily buildings, see Commercial Boiler Tune-Up measure.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{unit} \times \frac{EFLH_{heating}}{100} \times ESF$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
$kBTU/h_{in}$ = Nameplate capacity gas input rating (kBTU/h)
$EFLH_{heating}$ = Equivalent full-load heating hours
ESF = Energy savings factor
100 = Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTU/h_{in}$		From application.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
ESF	0.03	The energy savings factor for boiler tune-ups is used to estimate the annual heating energy savings.[249]

[249] Energy savings on the order of 2% - 5% were realized from a boiler tune-up program in the Pacific Northwest. Building Tune-Up and Operations Program Evaluation. Washington State University Energy Program, pg. 5.

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a residential gas-fired space heating boiler in a single family or low-rise multifamily building that has not received a tune-up in 5 years or more.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential gas-fired boiler that has undergone a tune-up in accordance with the manufacturer's recommendations.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Improved boiler efficiency as a result of a boiler tune-up will reduce the run time of the distribution system's circulator pumps and boiler combustion fan if so equipped. These effects are anticipated to be small and are not currently quantified for this measure.

References

1. Dethman and Kunkle, Building Tune-Up and Operations Program Evaluation. Washington State University Energy Program, 2007.
   Available from: https://library.cee1.org/system/files/library/1808/990.pdf

Record of Revision

Record of Revision Number	Issue Date
6-18-15	6/26/2018

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COMBINATION ("COMBI") BOILERS AND FURNACES

Measure Description

This measure covers the installation of residential gas combination or "combi" boilers and furnaces, which are defined as high-efficiency, instantaneous water heaters with a heating designation. Combi-boilers are all-in-one high-efficiency space heating systems with integrated capability for providing instantaneous domestic hot water, while combi-furnaces supply both domestic tankless hot water and forced air heating. These units realize energy savings through increased thermal efficiency and by taking cold water straight from the main supply and heating it as needed, which eliminates the need for a separate hot water storage tank and avoids standby losses. Qualifying equipment must be in accordance with ASHRAE Standard 124-2007 (RA 2016).[250] This measure only applies to systems with modulating/staging capability and no water storage tank.

This measure only captures the gas savings impacts of combi-boilers and combi-furnaces. While electric combi-boilers exist, more investigation and research are required before an approach for estimating associated energy savings can be developed.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = \Delta therms_{SH} + \Delta therms_{DHW}$$

$$\Delta therms_{SH} = units \times \frac{kBTU/h_{in}}{unit} \times \left(\frac{AFUE_{ee}}{AFUE_{baseline}} - 1\right) \times \frac{EFLH_{heating}}{100}$$

$$\Delta therms_{DHW} = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{RE_{baseline}} - \frac{1}{AFUE_{ee}}\right) + \frac{UA_{baseline}}{RE_{baseline}} \times \frac{\Delta T_{amb}}{100{,}000} \times 8{,}760\right]$$

where:

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

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[250] ASHRAE Standard 124-2007 (RA 2016) – Methods of Testing for Rating Combination Space-Heating and Water-Heating Appliances (ANSI Approved)

$\Delta therms$ = Annual gas energy savings
$\Delta therms_{DHW}$ = Annual domestic hot water savings associated with installation of a high-efficiency combi-boiler or combi-furnace
$\Delta therms_{SH}$ = Annual space heating savings associated with installation of a high-efficiency combi-boiler or combi-furnace
units = Number of measures installed under the program
$kBTU/h_{in}$ = Space heating fuel input rating
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
AFUE = Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
$EFLH_{heating}$ = Heating equivalent full-load hours
GPD = Gallons per day
ΔT_{main} = Average difference between the cold inlet temperature and the hot water delivery temperature (°F)
RE = Recovery efficiency
UA = Overall heat loss coefficient (BTU/h-°F)
ΔT_{amb} = Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
100 = Conversion factor, (kBTU/therm), one therm equals 100 kBTU's
365 = Days in one year
8.33 = Energy required (BTU's), to heat one gallon of water by one degree Fahrenheit
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU's
8,760 = Hours in one year

Summary of Variables & Data Sources

Variable	Value	Notes/References
$kBTU/h_{in}$		Nominal heating input capacity is the nameplate input rating of the unit in kBTU/h, from application.
$AFUE_{baseline}$		See Baseline Efficiencies section below.
$AFUE_{ee}$		From application.
$EFLH_{heating}$		Lookup based on building type and location in Appendix G.
GPD	17.2 X # of people	Calculated based on number of people served by the system. If unknown, use 46 GPD.[251]
ΔT_{main}	$T_{set} - T_{main}$	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb}	70 $= T_{set} - T_{amb}$	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)

[251] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.

Variable	Value	Notes/References
T_{set}	140	Water heater set point temperature (°F).[252]
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).[253]
$RE_{baseline}$	0.75	Gas recovery efficiency.[254]
$UA_{baseline}$	7.85	Overall heat loss coefficient of the baseline condition (BTU/h-°F).[255]

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

City	Annual average outdoor temperature[257] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

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

[252] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)

[253] 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.

[254] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.

[255] 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 calculated for a minimally code compliant gas storage water heater 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). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the $UA_{baseline}$ term.

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

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

Baseline Efficiencies from which Savings are Calculated

Space Heating Component

The baseline efficiency for the space heating component of residential combi-boilers and combi-furnaces shall be consistent with code requirements for residential furnaces and boilers defined by the Energy Conservation Code of New York State[258], and the New York City Energy Conservation Code[259] as shown below based on the efficient equipment. The warm air furnace equipment type is applicable to combi-furnaces, and hot water boiler equipment type is applicable to combi-boilers.

Systems Serving Single-Family Homes or Single Units[260]

Equipment Type	Capacity Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225,000 BTU/h	0.80 AFUE	0.80 AFUE
Boiler, Hot Water, Gas Fired	< 300,000 BTU/h	0.82 AFUE	0.82 AFUE

Domestic Hot Water Component

The baseline condition is a standard efficiency 40-gallon storage type water heater with a recovery efficiency of 75%[261] and heat loss coefficient of 7.85 BTU/h-°F.[262]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a combi-boiler unit with a heating designation efficiency of 90% AFUE or greater or a combi-furnace unit with a heating designation efficiency of 92% AFUE. Qualifying systems must be equipped with modulating/staging capability and no water storage tank. Units shall be in accordance with ASHRAE Standard 124-2007 (RA 2016).[263]

[258] ECCCNYS 2016, Table C403.2.3(4) and Table C403.2.3(5)
[259] NYCECC 2016; Table C403.2.3(4) and Table C403.2.3(5)
[260] 10 CFR 430.32(e)
[261] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[262] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1.
[262] 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 calculated for a minimally code compliant gas storage water heater 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). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the $UA_{baseline}$ term.
[263] ASHRAE Standard 124-2007 (RA 2016) – Methods of Testing for Rating Combination Space-Heating and Water-Heating Appliances (ANSI Approved)

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY are shown in Appendix G.

Domestic hot water heaters are assumed to be available for operation 8,760 hours per year, and it is assumed standby losses in the baseline case are incurred 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

High efficiency furnaces may be packaged with high efficiency cooling equipment and/or electronically commutated blower motors, which may provide electricity savings. Draft fans, when present, will increase electricity consumption.

References

1. ASHRAE Standard 124-2007 (RA 2016) – Methods of Testing for Rating Combination Space-Heating and Water-Heating Appliances (ANSI Approved)
2. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016
   Available from: http://www.waterrf.org/PublicReportLibrary/4309A.pdf
3. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from:
   https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
4. 10 CFR 430 Subpart B – Test Procedures, Appendix C1 - Uniform Test Method for Measuring the Energy Consumption of Dishwashers
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=9acb5e05dd1d96230c64079cf0c03102&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.c1
5. 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters
   Available from:
   https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf
6. AHRI Directory of Certified Product Performance
   Available from: https://www.ahridirectory.org/ahridirectory/pages/home.aspx
7. Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains

Water Temperature." National Renewable Energy Laboratory.
Available from: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.515.6885

8. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
9. ECCCNYS 2016, per IECC 2015; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers.
Available from: https://codes.iccsafe.org/public/document/IECC2015/chapter-4-ce-commercial-energy-efficiency
10. NYCECC 2016; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers
Available from:
https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
11. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8

Record of Revision

Record of Revision Number	Issue Date
9-18-16	9/28/2018

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HEAT PUMP - AIR SOURCE (ASHP)

Measure Description

This measure covers the installation of high-efficiency air source heat pumps in residential applications. An air source heat pump is a product, other than a packaged terminal heat pump, which is powered by single phase electric current, air cooled, rated below 65,000 BTU/h, not contained within the same cabinet as a furnace with rated capacity above 225,000 BTU/h, and operates as a heat pump. An air source heat pump may consist of a single-package unit or an outdoor unit and one or more indoor units, including multi-head mini-split systems.[264] The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local energy conservation code. Baseline and efficient equipment is assumed to include electric resistance supplemental heating of the same capacity. Thus, although rated capacity and efficiencies used in this measure incorporate supplemental heating elements, no savings are attributed to reduction in electric resistance heating capacity.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

$$\Delta kWh_{cooling} = units \times tons/unit \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling}$$

$$\Delta kWh_{heating} = units \times \frac{kBTU/h_{out}}{unit} \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}$$

Peak Coincident Demand Electric Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of units installed under the program
tons/unit	= Tons of air conditioning per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)

[264] 10 CFR 430.2

$(kBTU/h)_{out}$/unit= The nominal rating of the heating output capacity of the heat pump in kBTU/h (including supplemental heaters) per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)

ee = Energy efficient condition or measure

baseline = Baseline condition or measure

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)

SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, used for average U.S. location/region

EER = Energy efficiency ratio under peak conditions

$EFLH_{cooling}$ = Cooling equivalent full-load hours

$EFLH_{heating}$ = Heating equivalent full-load hours

CF = Coincidence factor

12 = (kBTU/h)/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application, default to average system size from applications if unknown
$kBTU/h_{out}$		From application
$SEER_{baseline}$		Lookup from Baseline Efficiencies table below based on product class and size.
$SEER_{ee}$		From application
$EFLH_{cooling}$		Lookup based on building type, vintage and location from Appendix G.
$HSPF_{baseline}$		Lookup from Baseline Efficiencies table below based on product class and size.
$HSPF_{ee}$		From application
$EFLH_{heating}$		Lookup based on building type, vintage and location from Appendix G.
$EER_{baseline}$		Lookup from Baseline Efficiencies table below based on product class and size.
EER_{ee}		From application
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[265]

[265] 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 the Mid-Atlantic TRM Version 7.0 published May 2017 and 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.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an air source heat pump as defined in the Measure Description section above, with rated SEER, EER and HSPF per the table below. The SEER and HSPF values listed in the table below reflect the minimum performance required by federal standards. Minimum EER requirements are not specified by federal standards for the state of New York, nor are they mandated by state or city code for residential equipment. For this equipment, baseline EER is established as follows[266]:

$$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$$

Resultant values from application of this equation are tabulated in the baseline efficiencies table below.

Product Class	Seasonal Energy Efficiency Ratio (SEER)[267]	Energy Efficiency Ratio (EER)	Heating Seasonal Performance Factor (HSPF)[268]
Split System – Heat Pump (<45 kBTU/h)	14.0	11.8	8.2
Split System – Heat Pump (≥45 and < 65 kBTU/h)	14.0	11.8	8.2
Single Package – Heat Pump (<65 kBTU/h)	14.0	11.8	8.0

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an air source heat pump as defined in the Measure Description section above meeting minimum performance requirements dictated by program guidelines.

Operating Hours

Cooling and heating EFLH data by location, building type and vintage are tabulated in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Minor heating interactions are expected with efficient furnace fans utilized in most high efficiency air conditioners. These impacts are expected to be negligible and have not been addressed in the prescribed methodology at this time.

[266] DOE, Building America House Simulation Protocols, October 2010
[267] 10 CFR 430.32 (c)(1)
[268] 10 CFR 430.32 (c)(1)

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 430.2 Definitions.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
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1	10/15/2010
12-17-8	12/31/2017
9-18-4	9/28/2018

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HEAT PUMP – GROUND SOURCE (GSHP)

Measure Description

This measure covers the installation of a ground source heat pump (GSHP) system with a closed loop heat exchanger field, which provides heating and cooling for space conditioning by the water to air transference of ground temperatures through a typical air-duct distribution system in a detached single-family residential home. This measure applies to GSHPs with a rated cooling capacity of <65,000 BTU/h. The baseline efficiency used for a GSHP is the efficiency level of the minimally code compliant replacement equipment for the existing heating and cooling systems. The GSHP analysis associated with this measure is based on several assumptions consistent with best practice design for a detached single-family residential building:

ECCCNYS states systems shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.[269]

The building peak heating load in New York typically exceeds the peak cooling load, therefore it is assumed that the GSHP runs at part-load during peak cooling hours.

The ground loop heat exchanger is adequately sized and installed properly to allow the GSHP to meet the peak heating load without electric resistance auxiliary heat.

The GSHP is equipped with either a two stage or variable speed compressor system, a variable speed or constant speed ground loop circulator pump, and a variable-speed blower distribution fan. This is a compliance requirement for application of this measure.

The GSHP efficiency is rated in accordance with ISO-13256, and performance tables are provided by the manufacturer showing the efficiency and capacity of the unit under full and part load conditions.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left\{ \begin{array}{c} \left[ACL \times \frac{1}{1{,}000} \times \left(\frac{F_{CEC}}{EER_{baseline}} - \frac{1}{EER_{part\ adj,ee}} \right) \times EFLH_{cooling} \times F_{EFLH} \right] \\ + \\ \left[AHL \times \frac{1}{1{,}000} \times \left(\frac{F_{EH}}{COP_{baseline}} - \frac{1}{COP_{part\ adj,ee}} \right) \times \frac{EFLH_{heating} \times F_{EFLH}}{3.412} \right] \end{array} \right\}$$

[269] ECCCNYS 2016, Section R403.7

Peak Coincident Demand Savings

$$\Delta kW = ACL \times \frac{1}{1{,}000} \times \left(\frac{F_{CEC}}{EER_{baseline}} - \frac{1}{EER_{part\ adj,ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = AHL \times \frac{1}{100{,}000} \times \frac{F_{GH}}{AFUE_{baseline}} \times EFLH_{heating} \times F_{EFLH}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand savings
Δtherms	= Annual fossil fuel savings
ACL	= Actual cooling load (BTU/h)
AHL	= Actual heating load (BTU/h)
F_{CEC}	= Central electric cooling factor; used to account for the presence or absence of a central electric cooling system
F_{EH}	= Electric heating factor; used to account for the presence or absence of an electric heating system
F_{GH}	= Gas heating factor; used to account for the presence or absence of a gas heating system
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
EER	= Energy efficiency ratio (BTU/watt-hour)
COP	= Coefficient of performance, ratio of output energy/input energy
$EER_{part\ adj}$	= Energy efficiency ratio (BTU/watt-hour) at part-load adjusted for fan and pump power
$COP_{part\ adj}$	= Coefficient of performance, ratio of output/input energy at part-load adjusted for fan and pump power
AFUE	= Annual fuel utilization efficiency, seasonal efficiency for fuel heat equipment
$EFLH_{cooling}$	= Cooling equivalent full-load hours
$EFLH_{heating}$	= Heating equivalent full-load hours
F_{EFLH}	= Adjustment factor to account for oversizing assumption embedded in EFLH
CF	= Coincidence Factor
1,000	= Conversion factor, one kW equals 1,000 Watts
3.412	= Conversion factor, one watt-hour equals 3.412 BTU
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
ACL		Determine based on Manual J calculation.
AHL		Determine based on Manual J calculation.
F_{CEC}		If a central electric cooling system is present, set equal to 1. Otherwise, set equal to 0.

Variable	Value	Notes
F_{EH}		If a central electric heating system is present, set equal to 1. Otherwise, set equal to 0.
F_{GH}		If a central gas heating system is present, set equal to 1. Otherwise, set equal to 0.
$EER_{baseline}$		Electric cooling energy efficiency rating of baseline equipment. See Baseline Efficiency section below for details.
$COP_{baseline}$		Electric heating energy efficiency rating of baseline equipment. See Baseline Efficiency section below for details.
$EER_{part\ adj,\ ee}$		Energy efficiency ratio from the manufacturer's catalog data adjusted to account for applied fan and pump power. See Compliance Efficiency section below for details.
$COP_{part\ adj,\ ee}$		Coefficient of performance (ratio of heat delivered to energy input to the compressor) from the manufacturer's catalog data adjusted to account for applied fan and pump power. See Compliance Efficiency section below for details.
$AFUE_{baseline}$		Gas heating energy efficiency rating of baseline equipment. See Baseline Efficiency section below for details.
EFLH		Lookup based on building type and location from Appendix G
F_{EFLH}	1.25	Adjustment factor to EFLH to account for oversizing assumption embedded in EFLH data presented in Appendix G. (see Operating Hours section below)
CF	0.69	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.69.[270]

Baseline Efficiencies from Which Savings are Calculated

The baseline efficiency used for a GSHP is the efficiency level of the minimally code compliant replacement equipment for the existing heating and cooling systems. The minimally code compliant efficiency level shall comply with the requirements of the current state code, or under state law, an equal or more stringent code or standard adopted by the municipality or jurisdiction applicable to the installation site.

For example, the baseline efficiency level for a 3-ton GSHP with existing equipment in a normal/end-of-life replacement scenario in New York State (and where more stringent code is not

[270] 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 the Mid-Atlantic TRM Version 7.0 published May 2017 and 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. The TRM MC continues to coordinate with the New York Geothermal Energy Organization ("NY GEO") regarding right sizing adjustment factors and the use of coincidence factor.

enforced) would be: 1) For electric equipment, a split-system air conditioner with a SEER of 13[271] or an air-source heat pump with a SEER of 14 and HSPF of 8.2[272]; 2) For fossil fuel equipment, with an existing natural gas furnace, an equivalent baseline efficiency, stated as the Annual Fuel Utilization Efficiency (AFUE), would be 80%[273]. Note, the baseline efficiency for electric resistance heat is a COP of 1.0. For electric resistance heating, no fan or pump power is considered.

Current code (Code of Federal Regulations 10 CFR 430.32, ECCCNYS 2016, NYCECC 2016 or local legislation) applicable to the installation site should be consulted for correct baseline system and efficiency values.

The baseline electric cooling efficiency term used for this measure is in terms of EER. Minimum EER requirements are not specified by federal standards for the state of New York, nor are they mandated by state or city code for residential equipment. For this equipment, baseline EER is established as follows[274]:

$$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$$

Air source heat pumps are rated under a standard set of conditions. For cooling, the differences between the rated conditions and those in New York are small, however for heating, the differences between the rated conditions and those experienced in New York are significant. To account for these differences during the heating season, a climate-adjustment factor, as defined in the table below, must be used to define the project baseline when that baseline is an air source heat pump.

The HSPF is the AHRI rated heating seasonal average efficiency expressed in terms of BTU/watt-hour. A seasonal average adjusted part-load COP of an air-source heat pump is used in the above equations. This baseline/adjusted part-load COP shall be calculated as:

$$COP_{baseline} = COP_{part\ adj} = \frac{HSPF \times F_{HSPF}}{3.412}$$

where:

$COP_{part\ adj}$ = Seasonal average adjusted COP of air-source heat pump

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

F_{HSPF} = HSPF Climate Adjustment Factor, from table below

3.412 = Conversion factor, one watt-hour equals 3.412 BTU

HSPF Climate Adjustment Factor (F_{HSPF})

City	HSPF < 8.5	HSPF ≥ 8.5
Albany	0.70	0.67
Binghamton	0.68	0.65

[271] 10 CFR 430.32 (c)(1)(i)
[272] 10 CFR 430.32 (c)(1)(ii)
[273] 10 CFR 430.32 (e)(2)(i)(A) – Assumes an 80 kBTU/h output gas furnace.
[274] DOE, Building America House Simulation Protocols, October 2010

City	HSPF < 8.5	HSPF ≥ 8.5
Buffalo	0.73	0.70
Massena	0.59	0.56
NYC	0.80	0.78
Poughkeepsie	0.62	0.59
Syracuse	0.69	0.66

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a ground source heat pump system as defined in the Measure Description section above meeting or exceeding minimum performance requirements dictated by program eligibility guidelines.

Ground source heat pumps are rated according to ISO-13256. The efficiency specifications in ISO-13256 account for the compressor energy and supply fan, and pump energy required to overcome air and fluid pressure drop internal to the unit. The analysis is based on the actual building heating and cooling loads from a Manual J calculation, rather than the installed equipment nameplate capacity. Thus, the analysis uses an adjustment factor to remove the embedded oversizing assumptions in the Appendix G EFLH data. The ISO-13256 efficiency rating procedure addresses the efficiency of the GSHP only, not the entire system. The fan energy required to distribute air through the duct system and the pump energy required to move the heat transfer fluid through the ground loop is accounted for separately in this analysis.

The seasonal average cooling and heating efficiencies are estimated from the manufacturers' catalog EER and COP data at the cooling and heating seasonal average entering fluid temperature and capacity. EER and COP ratings provided in manufacturers' catalogs were developed under conditions specified in ISO 13256, which do not include fan and pump power external to the unit. An adjustment factor is applied to the manufacturers' catalog data to account for fan and pump power:

$$EER_{part\ adj} = \left(EER_{part}\ at\ GWT_{cooling}\right) \times F_{cooling}$$

$$COP_{part\ adj} = \left(COP_{part}\ at\ GWT_{heating}\right) \times F_{heating}$$

Summary of Variables and Data Sources

Variable	Value	Source
$GWT_{cooling}$	60	Heat pump entering water temperature (°F). Data source; monitored ground loop temperature data from geothermal heat pump systems installed in NY (see reference 7). The data was recorded on a daily basis over a 12-month period, including a full cooling season.
$GWT_{heating}$	40	Heat pump entering water temperature (°F). Data source; monitored ground loop temperature data from geothermal heat pump systems installed in NY (see reference 7). The data was recorded on a daily basis over a 12-month period, including a full heating season.

Variable	Value	Source
$F_{cooling}$		Adjustment factor to the manufacturers' catalog data is applied to account for fan and pump power consumption during cooling mode
$F_{heating}$		Adjustment factor to the manufacturers' catalog data is applied to account for fan and pump power consumption during heating mode

Data concerning the external static pressure (ESP) imposed on the unit during ISO testing are not generally available. It is assumed that the ESP during the test is representative of the ESP of a typical duct system. Pump power for a well-designed system from the ASHRAE Geothermal Heating and Cooling System Design Guide is shown below:

Installed Pump Power	Power into Pump Motor	Grade	Available Head with 70% Efficient Pump at 3gpm/ton
<5hp/100 tons	< 45 W/ton	A	< 46 ft. of water

The EER and COP ratings provided in manufacturers' catalogs were developed under conditions specified in ISO 13256, which do not include fan and pump power external to the unit. An adjustment factor to the manufacturers' catalog data as a function of external pumping power are shown below for variable-speed and constant two-speed ground-water pumping systems:

Heat Pump Type	Stage	Pump power (W/ton)	Pump Type	$F_{cooling}$	$F_{heating}$
Variable	Low	45	Variable flow	0.85	0.93
Two-stage	Low	45	Variable flow	0.84	0.91
Variable	Low	45	Constant flow	0.75	0.86
Two-Stage	Low	45	Constant flow	0.8	0.88

Operating Hours

Operating hours are based on EFLH as presented in Appendix G. Note, the EFLH data in Appendix G are based on system nameplate capacity, while the equations in this section are based on actual building load. The F_{EFLH} factor is introduced to account for the equipment oversizing assumption embedded in the Appendix G data. The oversizing assumption embedded in the Appendix G data are appropriate for equipment sized to meet the peak-cooling load, such as central air conditioners and air source heat pumps. However, GSHPs are typically sized to meet the heating load; and the oversizing assumptions embedded in the Appendix G data are not appropriate.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

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8. *Water Source Heat Pumps – Testing and Rating for Performance – Part 1: Water to Air and Brine to Air Heat Pumps* (2012) Arlington, VA. ANSI/ASHRAE/ISO Standard 13256-1:1998 (RA 2012), AHRI, 2012.
9. *Manual J Residential Load Calculation*, Arlington, VA. Air Conditioning Contractors Association
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11. Monitored data from geothermal heat pump systems installed in New York State submitted August 2015 by the New York Geothermal Energy Organization, and reviewed by NYS DPS Staff.

Record of Revision

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1	10/15/2010
4-16-1	3/31/2016
6-17-6	6/30/2017
3-18-11	3/29/2018

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

OUTDOOR TEMPERATURE SETBACK CONTROL FOR HYDRONIC BOILER

Measure Description

This measure covers the installation of outdoor temperature setback control for single and multi-family residential gas boilers. Outdoor temperature setback control adjusts the hot water set point temperature of the boiler in response to outdoor air temperature. This measure is only applicable to retrofit of existing boiler systems. One outdoor temperature setback measure may be applied to each boiler.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{unit} \times \frac{EFLH_{heating}}{100} \times ESF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$kBTU/h_{in}$	= Gas input rating (kBTU/h)
$EFLH_{heating}$	= Equivalent full-load heating hours
ESF	= Energy savings factor
100	= Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTU/h_{in}$		From application.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.
ESF	0.05	Cadmus Group, Inc. [275]

[275] Cadmus Group, Inc., Home Energy Services Impact Evaluation, August 2012, pg. 20

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing single or multi-family residential boiler without outdoor temperature setback control.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an existing single or multi-family residential boiler equipped with outdoor temperature setback control.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Lower boiler set point temperatures may cause hot water circulators to run longer cycles. This impact is anticipated to be minor and is not quantified in this measure.

References

5. Cadmus Group, Inc., Home Energy Services Impact Evaluation, August 2012 Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Home-Energy-Services-Impact-Evaluation-Report_Part-of-the-Massachusetts-2011-Residential-Retrofit-and-Low-Income-Program-Area-Evaluation.pdf

Record of Revision

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0	10/15/2010
6-16-4	6/30/2016
6-18-6	6/26/2018

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STEAM TRAP REPAIR OR REPLACEMENT – LOW PRESSURE SPACE HEATING

Measure Description

This measure covers the repair or replacement of steam traps in low-pressure (≤15 psig) on existing residential steam systems served by gas-fired boilers. Steam systems distribute heat from boilers to satisfy space heating requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to ensure correct operation. Faulty steam traps (leaking or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam production. There are three major types of steam traps that are applicable: 1) thermostatic (including float and thermostatic) 2) mechanical and 3) thermodynamic.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

$$Loss_{steam} = 24.24 \times Dia^2 \times P_a \times 0.5$$

$$P_a = psig + psia$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of steam traps repaired/replaced under the program
$Loss_{steam}$	= Hourly steam loss per failed trap (lb/hr)
24.24	= Steam loss constant per Napier's equation (lb/hr-psia-in^2)
Dia	= Internal Diameter (I.D.) of steam trap orifice (inches)
P_a	= Absolute steam pressure (psi)

0.5	= Fraction of orifice open[276]
psig	= Steam gage pressure (psi)
psia	= Atmospheric pressure (psi)
ΔH_{vap}	= Heat of vaporization (latent heat), in BTU/lb, at system operating pressure (psig)
Eff	= Efficiency of boiler
$EFLH_{heating}$	= Equivalent full-load heating hours
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU's

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$		Calculated per the equation above, dependent upon system operating pressure (psig) and steam trap orifice diameter (Dia).
Dia		Steam trap orifice diameter (in), from application
P_a		Calculated per the equation above, dependent upon system operating pressure (psig).
psig		Steam boiler operating pressure (psi), from application
psia	14.7	Atmospheric pressure (psi)
ΔH_{vap}		Look up from table below based on system operating pressure (psig)
Eff		Boiler efficiency, from application. Either E_t or AFUE shall be used, based on nameplate rating metric of existing equipment.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.

Heat of Vaporization (BTU/lb)[277]

Pressure (psig)	Heat of Vaporization (BTU/lb)
0	970
1	968
2	966
3	964
4	962
5	961
6	959
7	957
8	956
9	954
10	953
11	951
12	950
13	948
14	947

[276] Conservative estimate typically used by steam trap manufacturers/vendors to estimate savings; Enbridge adjustment factor used as referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012 and DOE Federal Energy Management Program Steam Trap Performance Assessment.
[277] Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases (1936)

Pressure (psig)	Heat of Vaporization (BTU/lb)
15	946

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a steam trap failed open on a low-pressure steam space heating system.

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Joseph Henry Keenan and Frederick G. Keyes, Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases, John Wiley and Sons, New York (1936)

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6-18-16	6/26/2018

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SUBMETERING

Measure Description

This measure covers the installation of submeters for individual apartments in multi-family buildings in order to charge tenants for electric consumption according to their metered usage. Submetering achieves savings by tying tenant electric usage to utility cost, financially encouraging tenants to consume less energy. Submeter service providers are required to comply with the NYS Public Service Law and all applicable Commission rules and regulations, including but not limited to New York State Codes, Rules and Regulations (NYCRR) Title 16 part 96.[278]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{kWh}{ft^2} \times ft^2 \times ESF$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
kWh/ft^2	= Annual electric energy consumption per square foot of conditioned floor area subject to submetering
ft^2	= Total conditioned floor area of tenant spaces subject to submetering
ESF	= Energy savings factor
CF	= Coincidence factor
8,760	= Hours in one year

[278] New York Codes, Rules and Regulations (NYCRR) Title 16. NYS Department of Public Service Chapter II. Electric Utilities Part 96. Residential Electric Submetering.

Summary of Variables and Data Sources

Variable	Value	Notes
kWh/ft^2		From application. Annual energy consumption per square foot of conditioned floor area should be either site-specific and adjusted to exclude common areas or based on utility territory specific evaluation of typical tenant energy consumption. It is the responsibility of the utility to establish these values.
ft^2		From application.
ESF	0.10	NYSERDA Electrical Submetering Manual. [279]
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0. [280]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a multifamily building that is master metered for electric service.

Compliance Efficiency from which Incentives are Calculated

The efficient condition is a multi-family building with regulation compliant electric submetering.

Operating Hours

Submetering hours are not utilized in the estimation of energy savings, but meters are assumed to be operational 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Submetering results in more energy conscious tenants, which may translate to indirect fossil fuel savings. However, due to the uncertainty in the reliability of indirect fossil fuel savings, these impacts have not been quantified at this time.

Ancillary Electric Savings Impacts

N/A

[279] NYSERDA Electrical Submetering Manual, conservative end of reported 10-26% savings of residential submetering. However, given the scarcity of recent, reliable studies, it is particularly important that savings from submetering be rigorously evaluated through ex-post studies.
[280] *No source specified – update pending availability and review of applicable references.*

References

1. New York State Codes, Rules and Regulations (NYCRR) Title 16. NYS Department of Public Service Chapter II. Electric Utilities Part 96. Residential Electric Submetering. Available from: http://www3.dps.ny.gov/N/nycrr16.nsf/Parts/35C27BA3E98C80E085256FC7004FC859
2. NYSERDA Electrical Submetering Manual

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0	10/15/2010
9-18-5	9/28/2018

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THERMOSTAT - LEARNING

Measure Description

This measure covers the installation of ENERGY STAR® qualified smart thermostats with behavioral learning capabilities applied to single-family and multi-family residential HVAC systems. Utilizing Wi-Fi connections, a smart (learning) thermostat provides and receives feedback from users to enhance energy efficiency without compromising comfort. A learning thermostat controls HVAC equipment to regulate the temperature of the room or space in which it is installed, communicates with sources external to the HVAC system for remote adjustment and has the ability to perform automatic adjustments in response to occupant behavior. Additional learning thermostat capabilities may vary, but at minimum, must meet the following criteria:

- Work as a basic thermostat in absence of connectivity to the service provider.
- Give residents some form of feedback about the energy consequences of their settings.
- Provide information about HVAC energy use, such as monthly run time.
- Provide the ability to set a schedule.
- Provide the ability to work with utility programs to prevent brownouts and blackouts, while preserving consumers' ability to override those grid requests.[281]

This measure is applicable to single and multi-family centralized heating and cooling systems. For single family applications with multiple zones, energy savings are per residence. While incentives may be provided for multiple thermostat units, the algorithms below shall apply a value of "1" to the "units" term. For multifamily applications, "tons/unit", "$(kBTU/h)_{out}$/unit" and "$(kBTU/h_{in})$/unit" terms shall be set equal to the total capacity of the central cooling/heating system divided by the total number of dwelling units served by the system. The "units" term shall be set equal to the total number of dwelling units in which learning thermostats are installed. This measure is not applicable to multifamily central heating systems with additional capacity for domestic hot water.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\left(tons/unit \times \frac{12}{Eff_{cooling}} \times EFLH_{cooling} \times ESF_{cooling} \times F_{CEC}\right) + \left((kBTU/h)_{out}/unit \times \frac{1}{HSPF} \times EFLH_{heating} \times ESF_{heating} \times F_{EH}\right)\right]$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

[281] ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0, January 2017

Annual Gas Energy Savings

$$\Delta therms = units \times \left((kBTU/h)_{in}/unit \times \frac{1}{100} \times EFLH_{heating} \times ESF_{heating} \times F_{GH} \right)$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas savings
units = Number of residences in which the measure is installed under the program
tons/unit = Tons of air conditioning per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total cooling capacity of the system divided by the total number of dwelling units it serves
$(kBTU/h)_{out}$/unit= Output electric heating capacity in kBTU/h per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total heating capacity of the system divided by the total number of dwelling units it serves
$(kBTU/h)_{in}$/unit = Input heating capacity in kBTU/h per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total heating capacity of the system divided by the total number of dwelling units it serves
$Eff_{cooling}$ = Seasonal average energy efficiency over the cooling season, BTU/watt-hour, (used for average U.S. location/region), using either SEER (<5.4 tons) or IEER (≥5.4 tons)
HSPF = Seasonal average energy efficiency over the heating season, Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heat) 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
$EFLH_{cooling}$ = Cooling Equivalent full-load hours
$EFLH_{heating}$ = Heating Equivalent full-load hours
ESF = Energy savings factor
F_{CEC} = Central electric cooling factor; used to account for the presence or absence of a central electric cooling system
F_{EH} = Electric heating factor; used to account for the presence or absence of an electric heating system
F_{GH} = Gas heating factor; used to account for the presence or absence of a gas heating system
12 = (kBTU/h)/ton of air conditioning capacity
100 = Conversion factor, one therm equals 100 kBTU

Summary of Variables & Data Sources

Variable	Value	Notes
tons/unit		From application or use 3 tons as a default.[282]
$(kBTU/h)_{out}$/unit		From application or use 72 kBTU/h as a default.[283]
$(kBTU/h)_{in}$/unit		From application or use 90 kBTU/h as a default.[284]
$Eff_{cooling}$		From application or use 14 SEER, assuming a 3-ton central ASHP system.[285]
HSPF		From application or use 8.2 HSPF, assuming a 3-ton central ASHP system. [286] 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.
$EFLH_{cooling}$		Look up based on building type, vintage and city in Appendix G.
$EFLH_{heating}$		Look up based on building type, vintage and city in Appendix G.
$ESF_{cooling}$	0.10	Energy savings factor for cooling.[287]
$ESF_{heating}$	0.08	Energy savings factor for heating.[288]
F_{CEC}	Central Cooling: 1 No Central Cooling: 0 Unknown: 0.39	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[289]
F_{EH}	Electric Heating: 1 No Electric Heating: 0 Unknown: 0.15	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[290]
F_{GH}	Gas Heating: 1 No Gas Heating: 0 Unknown: 0.60	Based on EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States.[291]

Coincidence Factor (CF)

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

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282 Assumes a 1,800 ft^2 home with 20 BTU/h-ft^2 cooling load: 1,800 ft^2 x 20 BTU/h-ft^2 x 1/12,000 ton/(BTU/h) = 3 tons

283 Assumes a 1,800 ft^2 home with 40 BTU/h-ft^2 heating load: 1,800 ft^2 x 40 BTU/h-ft^2 x 1/(1,000 kBTU/h)/(BTU/h) = 72 kBTU/h

284 Assumes a 1,800 ft^2 home with 40 BTU/h-ft^2 heating load and 80% AFUE: 1,800 ft^2 x 40 BTU/h-ft^2 x 1/0.80 x 1/(1,000 kBTU/h)/(BTU/h) = 90 kBTU/h

285 10 CFR 430.32 (c)(1)

286 Ibid.

287 ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0, January 2017, pg. 10

288 Ibid.

289 EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC7.7 (“Unknown” calculated as the number of homes with central AC divided by the total number of homes)

290 EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC6.7 (“Unknown” calculated as the number of homes with electric heat divided by the total number of homes)

291 EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC6.7 (“Unknown” calculated as the number of homes with natural gas heat divided by the total number of homes)

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an HVAC system controlled by a programmable thermostat without Wi-Fi or behavioral learning capability.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an HVAC system controlled by an ENERGY STAR® qualified Wi-Fi communicating thermostat with behavioral learning capability as defined in the Measure Description section above.

Operating Hours

Cooling and heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for single and multi-family buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Reduced operating hours during the heating and cooling season result in distribution blower electric savings. These effects are not quantified in the prescribed savings estimation methodology for this measure at this time.

References

1. ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0, January 2017
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf
2. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
3. EIA Residential Energy Consumption Survey (RECS) 2015 Survey Data for Middle Atlantic States.
   Available from: https://www.eia.gov/consumption/residential/data/2015/

Record of Revision

Record of Revision Number	Issue Date
3-18-17	3/29/2018

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THERMOSTAT – PROGRAMMABLE SETBACK

Measure Description

Programmable setback thermostats applied to single-family and multi-family residential air conditioners, heat pumps, boilers, furnaces and electric resistance baseboard heating systems.

One programmable thermostat may be applied to each controlled HVAC system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\left(tons/unit \times \frac{12}{Eff_{cooling}} \times EFLH_{cooling} \times ESF_{cooling}\right) + \left((kBTU/h)_{out}/unit \times \frac{1}{HSPF} \times EFLH_{heating} \times ESF_{heating}\right)\right]$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left((kBTU/h)_{in}/unit \times \frac{1}{100} \times EFLH_{heating} \times ESF_{heating}\right)$$

where:

ΔkWh = Annual electric energy savings

ΔkW = Peak coincident demand electric savings

Δtherms = Annual gas savings

units = Number of residences in which the measure is installed under the program

tons/unit = Tons of air conditioning per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total cooling capacity of the system divided by the total number of dwelling units it serves

$(kBTU/h)_{out}$/unit= Output electric heating capacity in kBTU/h per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total heating capacity of the system divided by the total number of dwelling units it serves

$(kBTU/h)_{in}$/unit = Input heating capacity in kBTU/h per residence, based on nameplate data; for multifamily buildings with centralized HVAC, this term shall be set equal to the total heating capacity of the system divided by the total number of dwelling units it serves

$Eff_{cooling}$ = Seasonal average energy efficiency over the cooling season, BTU/watt-hour, (used for average U.S. location/region), using either SEER (<5.4 tons) or IEER (≥5.4 tons)

HSPF = Seasonal average energy efficiency over the heating season, Heating seasonal performance factor, BTU/watt-hour, total heating output (supply heat) in BTU (including resistance heat) 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

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

$EFLH_{heating}$ = Heating Equivalent full-load hours

ESF = Energy savings factor

12 = (kBTU/h)/ton of air conditioning capacity

100 = Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application or use 3 tons as a default.[292]
$(kBTU/h)_{out}$/unit		From application or use 72 kBTU/h as a default.[293]
$(kBTU/h)_{in}$/unit		From application or use 90 kBTU/h as a default.[294]
$Eff_{cooling}$		From application or use 14 SEER, assuming a 3-ton central ASHP system.[295]
HSPF		From application or use 8.2 HSPF, assuming a 3-ton central ASHP system. [296] 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.
$EFLH_{cooling}$		Look up based on building type, vintage and city in Appendix G.
$EFLH_{heating}$		Look up based on building type, vintage and city in Appendix G.
$ESF_{cooling}$	0.09	Energy savings factor for cooling.
$ESF_{heating}$	0.02	Energy savings factor for heating.

The nominal rating of the cooling capacity of the air conditioner or heat pump should be set equal to the rated capacity of all cooling equipment in the residence. The energy savings should be calculated based on the capacity of the HVAC system, with one thermostat controlling the system. For multifamily with central HVAC, total cooling capacity of the system should be used.

The nominal rating of the heating capacity of the heat pump should be set equal to the rated capacity of all heating equipment controlled in the residence. The energy savings should be

[292] Assumes a 1,800 ft^2 home with 20 BTU/h-ft^2 cooling load: 1,800 ft^2 x 20 BTU/h-ft^2 x 1/12,000 ton/(BTU/h) = 3 tons

[293] Assumes a 1,800 ft^2 home with 40 BTU/h-ft^2 heating load: 1,800 ft^2 x 40 BTU/h-ft^2 x 1/(1,000 kBTU/h)/(BTU/h) = 72 kBTU/h

[294] Assumes a 1,800 ft^2 home with 40 BTU/h-ft^2 heating load and 80% AFUE: 1,800 ft^2 x 40 BTU/h-ft^2 x 1/0.80 x 1/(1,000 kBTU/h)/(BTU/h) = 90 kBTU/h

[295] 10 CFR 430.32 (c)(1)

[296] Ibid.

calculated based on the capacity of the HVAC system, with one thermostat controlling the system. For multifamily with central HVAC, total heating capacity of the system should be used.

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline system is a standard, non-programmable thermostat for a central heating and cooling system when a programmable thermostat is not otherwise required by applicable energy conservation code. If programmable thermostats are required by code, no deemed savings exist.

The baseline efficiency for air conditioners and heat pumps should be set according to the sections on air conditioner and heat pump efficiency above. Electric resistance heating systems should use an HSPF = 3.412, which is equivalent to a coefficient of performance of 1.0.

Studies of residential heating thermostat set point behavior indicate some amount of manual setback adjustment in homes without programmable thermostats. This behavior is accounted for in the prototypical building simulation model used to calculate heating equivalent full-load hours, as described in Appendix A. An assumption of 3°F of night time setback behavior is embedded in the models.

Compliance Efficiency from which Incentives are Calculated

The energy savings factor for heating ($F_{heating}$) is the ratio of the energy savings resulting from installation of a programmable setback thermostat to the annual heating energy. The heating energy savings factor assumption is derived from the results of a New York State specific residential gas program evaluation conducted by Opinion Dynamics. This evaluation indicated a 2-4% reduction in total annual gas consumption resulting from installation of programmable thermostats. A conservative value of 2% of the annual heating energy consumption is assumed as deemed savings for programmable setback thermostats in residential applications.

The cooling energy savings factor ($F_{cooling}$) is the ratio of the energy savings resulting from installation of a programmable setback thermostat to the annual cooling energy. The cooling energy savings factor assumption is taken from the ENERGY STAR® website. The ENERGY STAR® calculator estimates an energy savings of 6% of the annual cooling energy consumption per degree of setback for programmable setback thermostats in residential applications. This measure assumes an average of 1.5 degrees of setback over the cooling season for an estimated annual cooling energy savings of 9%.

Operating Hours

Cooling and heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical single and multi-family residential buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for single and multi-family buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Reduced operating hours during the heating and cooling season result in distribution blower electric savings. These effects are not quantified in the prescribed savings estimation methodology for this measure at this time.

References

1. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
2. For examples of studies on residential thermostat set point behavior, see the literature review conducted for the California Energy Commission project "Residential Thermostats: Comfort Controls in California Homes," CEC-500-03-026 Available from: http://eta-publications.lbl.gov/sites/default/files/lbnl-938e.pdf
3. Baseline thermostat setback assumptions taken from: Conner, C.C. and Lucas, R.L. 1990. Thermostat Related Behavior and Internal Temperatures Based on Measured Data in Residences. PNL-7465, Pacific Northwest Laboratory. Richland, WA. Available from: http://elcap.nwcouncil.org/Documents/Thermostat%20Related%20Behavior.PDF
4. Opinion Dynamics: New York Statewide Residential Gas High-Efficiency Heating Equipment Programs Evaluation of 2009-2011 Programs; August 2014 Available from: http://www.nationalfuelforthought.com/docs/psc-reports/EEPS_Opinion_Dynamics_Corporation_Residential_Rebate_Program_Statewide_Impact_Evaluation_Report_Completed_August_2014.pdf
5. Programmable thermostat savings for the cooling season taken from the ENERGY STAR® website: Available from: https://www.energystar.gov/sites/default/files/asset/document/ProgrammableThermostat_Calculator.xls

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
1	12/31/2015
1-17-3	12/31/2016
2-17-1	2/10/2017

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THERMOSTAT – WI-FI (COMMUNICATING)

Measure Description

This section covers Wi-Fi communicating thermostats without behavioral learning capability applied to single-family and multi-family residential air conditioners, heat pumps, boilers, furnaces and electric resistance baseboard heating systems. These communicating thermostats allow set point adjustment via a remote application.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Cooling)

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
(ΔkWh/unit)	104	Annual electric savings per installed thermostat, in kWh[297]
(ΔkW/unit)	0.23	Peak demand savings per installed thermostat, in kW[298]
(Δtherms/unit)	66	Annual gas savings per installed thermostat, in therms[299]

Coincidence Factor (CF)

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

[297] Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012
[298] Ibid.
[299] Ibid.

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

HVAC system operating hours are embedded in the deemed savings values associated with Wi-Fi communicating thermostats, which are based on metering results.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Cadmus Group, Inc. *"Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation"*, prepared for The Electric and Gas Program Administrators of Massachusetts, September 2012
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Wi-Fi-Programmable-Controllable-Thermostat-Pilot-Program-Evaluation_Part-of-the-Massachusetts-2011-Residential-Retrofit-Low-Income-Program-Area-Study.pdf
2. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: HV-ProgTStat.
   Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

Record of Revision Number	Issue Date
1-16-19	12/31/2015
9-17-1	9/30/2017

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<u>THERMOSTATIC RADIATOR VALVE – ONE PIPE STEAM RADIATOR</u>

Measure Description

Thermostatic Radiator Valves (TRV) are self-contained, self-operated valves that do not require ancillary power. They provide local control of room temperature by controlling the venting of air out of the radiator. TRVs are available for a variety of installation conditions utilizing either remote-mounted sensors or integral-mounted sensors by means of remote or integral set point adjustment. This measure is specifically a TRV in combination with an air vent installed at one or more radiators in a one-pipe steam space heating system in residential applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of TRV's installed
Δtherms/HDD	= Annual gas energy savings per Heating Degree Day (HDD), per TRV
HDD_{loc}	= Heating Degree Days based on location

Summary of Variables and Data Sources

Variable	Value	Notes
units		Number of TRV's installed, from application
Δtherms/HDD	0.004318	Average gas savings per HDD per unit[300]
HDD_{loc}		Look up based on location from Heating Degree Days section below

<u>Heating Degree Days</u>

For the purposes of this measure, Heating Degree Days are defined as the number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature

[300] Thermostatic Radiator Valve (TRV) Demonstration Project. Prepared by NYSERDA, Project Manager Norine Karins and the EME Group Project Manager Michael McNamara. NYSERDA report 95-14. September 1995.

below which buildings need to be heated. The HDD values listed in the table below are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using base 65° F.[301]

City	HDD_{loc}
Albany	6,680
Binghamton	7,193
Buffalo	6,617
Massena	8,196
NYC	4,671
Poughkeepsie	6,210
Syracuse	6,651

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing space heating system with manual control valves at freestanding radiators, convectors, or baseboard heating units.

Compliance Efficiency from which Incentives are Calculated

The measure is defined as the existing radiator, convector, or baseboard heater unit controlled by the thermostatic radiator valve.

Operating Hours

Evaluation of savings associated with installation of TRVs is dependent upon typical heating degree days as specified in the Summary of Variables and Data Sources above.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

[301] HDD taken from NCEI 1981-2010 climate normals

References

1. Thermostatic Radiator Valve (TRV) Demonstration Project. Prepared by NYSERDA, Project manager Norine Karins and the EME Group project manager Michael McNamara. NYSERDA report 95-14. September 1995.
   Available from: https://www.osti.gov/servlets/purl/119941
2. NYS Plumbing Code 2016, per 2015 International Plumbing Code, Appendix D – Degree Day and Design Temperatures Table D-101
   Available from: https://codes.iccsafe.org/public/document/IPC2015NY/appendix-d-degree-day-and-design-temperatures
3. NOAA National Centers for Environmental Information – NCEI 1981-2010 Normals
   Available from: http://www.ncdc.noaa.gov/cdo-web/datatools/normals

Record of Revision

Record of Revision Number	Issue Date
1-16-12	12/31/2015
6-17-7	6/30/2017

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ENERGY MANAGEMENT SYSTEM (EMS)

Measure Description

An Energy Management System (EMS) is a computer system designed specifically for the automated control and monitoring of building systems which optimize the use of energy, as consumed by heating, ventilation, air conditioning, and domestic hot water heating. An EMS operates building functions as efficiently as possible while maintaining a specified level of comfort through the use of electromechanical control mechanisms. In multifamily buildings, an EMS installed with indoor temperature sensors in apartments and other heated spaces can reduce energy consumption by optimizing boiler operation based on seasonal weather variations, use patterns, and self-diagnostic functions. The measure is defined as the installation of a new EMS, consisting of a central boiler control system that allows for staging/control of multiple boilers and monitors indoor temperature, stack temperature, outdoor temperature, and supply or return water temperature.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

ΔkWh = N/A

Peak Coincident Demand Savings

ΔkW = N/A

Annual Gas Energy Savings

$$\Delta therms = \frac{BTU/h_{in}}{100{,}000} \times EFLH_{heating} \times ESF$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
BTU/h_{in} = Furnace or boiler input rating
$EFLH_{heating}$ = Equivalent full-load hours
ESF = Energy Savings Factor for EMS
100,000 = Conversion factor, (BTU/h)/therm

Summary of Variables and Data Sources

Variable	Value	Notes
BTU/h_{in}		From application, furnace or boiler input rating, in BTU/h.
$EFLH_{heating}$		Lookup based on building type and location.

Variable	Value	Notes
ESF	0.22	Energy Savings Factor, from US Energy Group study[302]

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing boiler control system based on outdoor temperature reset.

Compliance Efficiency from which Incentives are Calculated

The measure is defined as the new installation of a complete EMS with the capability of controlling an existing boiler system based on indoor and outdoor temperature.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. The EFLH values for commercial buildings are identified in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. US Energy Group Case Study #241, prepared by Sherri Jean Katz.

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1-16-13	12/31/2015

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LIGHTING

LIGHT EMITTING DIODE (LED), COMPACT FLUORESCENT LAMP (CFL) AND OTHER LIGHTING

Measure Description

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

Beginning January 2014, the Energy Independence and Security Act of 2007 (EISA) regulations stipulated typical 60W and 40W lamp wattages to comply with 43W and 29W lamp wattage standards for rated lumen output ranges of 750-1049 and 310-749 lumens, respectively. Deemed baseline values for this measure will apply wattages based on lamp type and light output (lumens).[303]

Per EISA 2007, effective beginning January 1, 2020, if more stringent regulations are not put into effect by that date, the sale of general service lamps that do not meet a minimum efficiency standard of 45 lumens per watt will be prohibited.[304] As a result of this stipulation, deemed baseline wattages for non-exempt general service lighting will be reduced to reflect this requirement in the January 2020 NY TRM. This will have significant impact on estimated energy savings associated with replacement of general service lamps (20 – 70% depending on lumen output). This information is provided to inform future ETIP development.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{(W_{baseline} - W_{ee})}{1{,}000} \times hrs \times HVAC_g$$

[303] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 86
[304] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 89

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
W	= Rated wattage of lamp and/or fixture (Watts)
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
1,000	= Conversion factor, one kW equals 1,000 Watts
CF	= Coincidence factor
hrs	= Lighting operating hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor for peak demand at NYISO coincident summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption (therms/kWh)

Summary of Variables and Data Sources

Variable	Value	Notes
units		Number of lamps sold/distributed under the program, from application
W_{ee}		Energy efficient measure Watts, from application
$W_{baseline}$		Baseline measure Watts, from application or default values from applicable table in "Baseline Efficiencies…" section below
hrs	Interior Lamps: 1,168 Interior Fixtures: 913 Exterior: 1,643	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting.
$HVAC_c$	Exterior and Unconditioned Spaces: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$	Exterior and Unconditioned Space: 0	HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_g$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual natural gas energy consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	Interior: 0.082 Exterior: 0	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting.

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

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

Coincidence Factor (CF)

The prescribed value for the coincidence factor for interior lighting is 0.082. This factor was derived from an examination of studies throughout New England that calculated coincidence factors based on the definition of system peak period at the time, as specified by ISO-New England.[305]

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

Baseline Efficiencies from which Savings are Calculated

Rated wattage baseline values should reflect the guidance noted below based on bulb type and lumens in accordance with EISA standards. Note that deemed baseline wattages for non-exempt general service lighting will be reduced to reflect the EISA 2007 "Backstop Requirement" beginning with the January 2020 NY TRM, assuming more stringent requirements are not established. This requirement, prohibiting the sale of general service lamps that do not meet a minimum efficiency standard of 45 lumens per watt will have significant impact on estimated energy savings associated with replacement of general service lamps (20 – 70% depending on lumen output). [306]

<u>General Service Lamps</u>
Baseline wattage for general service lamps are found in the table below. Per EISA 2007 guidelines, a general service lamp is defined as a standard incandescent or halogen type lamp that:

(1) Is intended for general service applications;
(2) Has a medium screw base;
(3) Has a lumen range of not less than 310 lumens and not more than 2,600 lumens
(4) Is capable of being operated at voltage range at least partially within 110 and 130 volts.

Certain lamp types are exempt from EISA compliance, including reflector lamps (see Reflector/Flood Lamps section below), decorative and globe shape lamps (see Specialty Lamps section below) and three-way lamps. Baseline wattage for any of these exempt lamp types should reflect the values in column (c) of the table below, with the exception of those lamps defined in the Specialty Lamps or Reflector/Flood Lamps sections below. All other general service lamps should use the baseline wattage values in column (b), corresponding to the applicable lumen range identified in column (a). For standard lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage should be used. For a complete list and definitions of EISA-exempt lamp types, reference Sec. 321: Efficient Light Bulbs of Public Law 110-140.[307]

[305] Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures, Spring 2007, Table i-1
[306] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 89
[307] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 82-86

Lumen Range (a)	Post-EISA 2007 Incandescent Equivalent $W_{baseline}$ (b)	EISA-Exempt Incandescent Equivalent $W_{baseline}$ (c)
310 – 449	25	25
450 – 799	29	40
800 – 1,099	43	60
1,100 – 1,599	53	75
1,600 – 1,999	72	100
2,000 – 2,600	72	150

Specialty Lamps[308]

Baseline wattage for specialty lamps are found in the table below. Specialty lamps are defined as medium screw-base lamps that are globe, bullet, candle or decorative shaped. For specialty lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage should be used.

Lumen Range (decorative) (a)	Lumen Range (globe) (b)	Post-EISA 2007 Incandescent Equivalent $W_{baseline}$ (c)	EISA-Exempt Incandescent Equivalent $W_{baseline}$ (d)
70 – 89		10	10
90 – 149		15	15
150 – 299	250 – 349	25	25
300 – 499	350 – 499	29	40
500 – 699	500 – 574	43	60
	575 – 649	53	75
	650 – 1,099	72	100
	1,100 – 1,300	72	150

Reflector/Flood Lamps[309]

Baseline wattage for reflector and flood type lamps are found in the table below. For reflector and flood lamps that fall outside of the prescribed lumen ranges below, the manufacturer recommended baseline wattage should be used.

Bulb Type (a)	Lumen Range (b)	$W_{baseline}$ (c)
ER30, BR30, BR40, or ER40	200 – 299	30
	300 – 449	40
	450 – 499	45
	500 – 1,419	65

[308] The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures; Chapter 21: Residential Lighting Evaluation Protocol, National Renewable Energy Laboratory, December 2014, p. 8-11

[309] State of Pennsylvania Technical Reference Manual, PA Public Utilities Commission, June 2016, p. 21-22

Bulb Type (a)	Lumen Range (b)	$W_{baseline}$ (c)
R20	200 – 299	30
	300 – 449	40
	400 – 449	40
	450 – 719	45
All other R, PAR, ER, BR, BPAR, or similar bulb shapes, with diameter >2.25", other than those listed above	200 – 299	30
	300 – 599	40
	600 – 849	50
	850 – 999	55
	1,000 – 1,300	65

Compliance Efficiency from which Incentives are Calculated

Compliance efficiency and fixture/lamp specifications shall be dictated by program eligibility criteria.

Operating Hours

Lamps

Hours of operation for lamps are estimated to be 3.2 operating hours per day or 1,168 (3.2 x 365) hours per year. The 3.2 operating hours per day is a value derived from an extended (nine month – May through February) logger study conducted during 2003 in Massachusetts, Rhode Island, and Vermont[310] . The Connecticut 2008 Program Savings Documentation uses 2.6 hours per day, based on a 2003 Connecticut-based study. A study of the 2005-2006 residential lighting program for Efficiency Maine reports daily hours of use at 4.8 hours from the markdown program component and 3.2 from the coupon program component[311]. This value represents a trade-off among factors that may affect the extent to which any out-of New York State value is applicable to NY. These include such factors as differences between the study area and NY, related to maturity of the CFL markets, program comparability, consumer knowledge of CFLs, and mix of locations within the house (which affects average hours of use). On balance, in considering the data and reports reviewed to date, 3.2 appears to be the most reasonable prior to New York-specific impact studies. This value is appropriate for interior applications only. For exterior applications, assume a total of 1,643 hours which is based on updated results from the 2003 Nexus Market Research[312].

[310] "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1

[311] Process and Impact Evaluation of the Efficiency Maine Lighting Program, RLW Analytics, Inc, and Nexus Market Research Inc., April 10, 2007, Table 1-2, p. 12.

[312] Updated results from Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, presented in 2005 memo; http://library.cee1.org/content/impact-evaluation-massachusetts-rhode-island-and-vermont-2003-residentiallighting-programs

Fixtures

Hours of operation for fixtures are estimated to be 2.5 operating hours per day or 913 (2.5 x 365) hours per year. The 2.5 operating hours per day is a value derived from an extended (nine month – May through February) logger study conducted during 2003 in Massachusetts, Rhode Island and Vermont[313]. The Connecticut 2008 Program Savings Documentation uses 2.6 hours per day, based on a 2003 Connecticut-based study. A study of the 2005-2006 residential lighting program for Efficiency Maine reports daily hours of use at 2.4 for interior fixtures[314]. The proposed value represents a trade-off among factors that may affect the extent to which any value from outside of New York State is applicable to NY. These include such factors as differences between the study area and NY related to maturity of the CFL markets, program comparability, consumer knowledge of CFLs, and mix of locations within the house (which affects average hours of use). On balance, in considering the data and reports reviewed to date, 2.5 appears to be the most reasonable prior to New York specific impact studies.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

References

1. Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 82-86
   Available from: https://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf
2. Impact evaluations of residential lighting programs in several New England states reviewed in preparing the proposed hours-of-use values and coincidence factors include:
   a. Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs, prepared for Cape Light Compact, Vermont Public Service Department, National Grid Massachusetts and Rhode Island, Western Massachusetts Electric Company, NSTAR Electric, Fitchburg G&E by Nexus Market Research Inc., and RLW Analytics Inc., Oct 1, 2004.
      Available from: https://library.cee1.org/system/files/library/1308/485.pdf

[313] "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1

[314] Process and Impact Evaluation of the Efficiency Maine Lighting Program, RLW Analytics, Inc, and Nexus Market Research Inc., April 10, 2007, Table 1-2, p. 12.

b. Extended Residential Logging Results memo to Angela Li, National Grid, by Tom Ledyard, RLW Analytics Inc., and Lynn Hoefgen, Nexus Market Research Inc., May 2, 2005
c. Market Progress and Evaluation Report for the 2005 Massachusetts ENERGY STAR® Lighting Program, prepared for Cape Light Compact, National Grid – Massachusetts, NSTAR, Western Massachusetts Electric Company by Nexus Market Research Inc, RLW Analytics, Inc., Shel Feldman Management Company, Dorothy Conant. September 29, 2006.
Available from: https://library.cee1.org/system/files/library/1297/474.pdf
d. Process and Impact Evaluation of the Efficiency Maine Lighting Program, prepared for Efficiency Maine by Nexus Market Research Inc. and RLW Analytics Inc., April 10, 2007.
Available from: https://library.cee1.org/system/files/library/1386/564.pdf
3. Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007.
Available from:
https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/116_RLW_CF%20Res%20C&I%20ltg.pdf
4. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures; Chapter 21: Residential Lighting Evaluation Protocol, National Renewable Energy Laboratory, December 2014, p. 8-11.
Available from: http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter21-residential-lighting-evaluation-protocol.pdf
5. State of Pennsylvania Technical Reference Manual, PA Public Utilities Commission, June 2016, p. 21-22
Available from:
http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

Record of Revision

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1	10/15/2010
7-13-2	7/31/2013
6-15-3	6/1/2015
1-16-3	12/31/2015
1-17-4	12/31/2016
9-17-2	9/30/2017

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LIGHTING - CONTROL
(place-holder)

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MOTORS AND DRIVES

POOL PUMP

Measure Description

This measure covers the installation of ENERGY STAR® qualified multi-speed and variable frequency drive (VFD) residential inground pool pumps. Pool pump speeds vary based on the pump's operation. Filtration, for example, only requires half the flow rate of running a pool cleaner. Conventional pool pumps, with only one speed, are set to run at the higher speeds required of the pool cleaner and waste energy during filtration operation by running faster than necessary. An ENERGY STAR® certified pool pump can run at different speeds and be programmed to match the pool operation with its appropriate pool pump speed. The energy saved is considerable; reducing pump speed by one-half allows the pump to use just one-eighth as much energy.[315] After January 1, 2019, all pool pumps must be rated according to WEF.[316] Pool pumps that have earned this label use up to 70% less energy than non-qualified models.[317]

This measure is not applicable to community pools in multifamily housing complexes. This measure is applicable to pool pumps with a total horsepower rating between 0.75 and 3 HP and with 2- or 2.5-inch diameter piping. This measure is only applicable to multi-speed and VFD inground, or self-priming, pool pumps. While single-speed pumps, non-self-priming pumps, and pressure cleanser booster pumps are eligible under ENERGY STAR® qualified product criteria, there was a critical lack of information regarding ENERGY STAR® calculations and assumptions pertaining to this equipment available at the time of publication of this measure. The measure scope will be expanded as more information becomes available.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{60 \times days}{1{,}000} \times \left[\frac{GPM_{baseline} \times hrs_{baseline}}{WEF_{baseline}} - \frac{(F_{HS} \times GPM_{ee,HS} + F_{LS} \times GPM_{ee,LS}) \times (F_{HS} \times hrs_{ee,HS} + F_{LS} \times hrs_{ee,LS})}{WEF_{ee}}\right]$$

Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{hrs_{annual}} \times CF$$

[315] ENERGY STAR® Pool Pumps
https://www.energystar.gov/products/other/pool_pumps
[316] ENERGY STAR® Pool Pumps Version 2 and Version 3 Specification Cover Letter, April 2018
[317] ENERGY STAR® Pool Pump Fact Sheet, January 2018

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
days	= Number of operating days per year
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
$_{HS}$	= High speed operation
$_{LS}$	= Low speed operation
GPM	= Gallons per minute
hrs	= Hours of operation per day
WEF	= Weighted Energy factor (kgal/kWh)
F	= Weighting factor
hrs_{annual}	= Annual hours of operation
CF	= Coincidence factor
60	= Conversion factor, minutes per hour
1,000	= Conversion factor, one kgal equals 1,000 gallons

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$		Look up in Baseline Efficiencies section below, based on pool curve and nameplate hp.
$GPM_{ee,HS}$		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.
$GPM_{ee,LS}$		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.
$hrs_{baseline}$		From application. If unknown, use 11.4[318] as default, assuming two turnovers per day for baseline condition[319].
$hr_{ee,HS}$		From application. If unknown, use 2 as default.[320]
$hr_{ee,LS}$		From application. If unknown, use 10 as default.[321]
$WEF_{baseline}$		Look up in Baseline Efficiencies section below, based on pool curve and nameplate hp.
WEF_{ee}		From application, or look up in Compliance Efficiency section below, based on multi-speed or VFD pump inputs.

[318] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 8/8/2018)
[319] CEE℠ High Efficiency Residential Swimming Pool Initiative, January 2013, pg 33
[320] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps (accessed 8/8/2018)
[321] Ibid.

Variable	Value	Notes
F_{HS}	0.2	Code of Federal Regulations. [322]
F_{LS}	0.8	Code of Federal Regulations. [323]
days		From application. If unknown, use 122 as default, based on 4 months of operation per year.
hrs_{annual}		From application. If unknown, use 1,464 as default, based on 12 hours of operation per day, 122 days per year.
CF	0.362	

Default Values

The table below contains values for annual electric energy savings and peak coincident demand savings. These values were established by using the assumed values from the Summary of Variables and Data Sources table above. Default values additionally assume a 22,000-gallon pool, 2-inch diameter piping, a 1.5 hp baseline pump performing 2 turnovers per day lasting 11.4 hours, and a 1.0 hp qualifying pump performing 1 turnover per day lasting 12 hours. [324]

Pump Type	Rated in WEF	
	ΔkWh	ΔkW
Multi-Speed	1,974	0.488
VFD	2,211	0.547

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.362.[325]

Baseline Efficiencies from which Incentives are Calculated

The baseline condition is a non-ENERGY STAR® qualified single-speed pool pump. The values for baseline WEF and GPM are found in the table below, based on nameplate horsepower and pump curve. The pump curve compares the total head in feet of water to the flow rate of the water for a given pump at a given motor speed. For a system with 2-inch diameter piping, use Curve A designation values. For a system with 2.5-inch diameter piping, use Curve C designation values.

Pump Type and Variable	Nameplate Horsepower					
	3	2.5	2	1.5	1	0.75
Curve A – $WEF_{baseline}$	1.6	1.9	1.9	2.1	2.4	2.6
Curve A – $GPM_{baseline}$	73	68	65	64	60	53
Curve C – $WEF_{baseline}$	2.0	2.2	2.3	2.3	2.5	3.3
Curve C – $GPM_{baseline}$	102	93	89	78	76	65

[322] 10 CFR Appendix B to Subpart Y of Part 431 – Uniform Test Method for the Measurement of Energy Efficiency of Dedicated-Purpose Pool Pumps
[323] Ibid
[324] CEE[SM] High Efficiency Residential Swimming Pool Initiative, January 2013, pg 33
[325] Standards Driven Market Transformation; 20 Year Multifaceted Intervention Leads to DOE Pool Pump Standard, ACEEE, pg 5-6

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified multi or variable speed self-priming pool pump. Self-priming pool pumps must have a WEF (in kgal/kWh) equal to or greater than the equation below for pumps on curve C.[326]

$$\mathrm{WEF} \geq -230 \times \ln(\mathrm{hhp}) + 6.59$$

where:

hhp = hydraulic horsepower, equal to or greater than 0.711

Multi-Speed Pumps

Typical WEF and GPM at high and low speeds for ENERGY STAR® multi-speed pool pumps are found in the table below, based on nameplate horsepower and pump curve. The pump curve compares the total head in feet of water to the flow rate of the water for a given pump at a given motor speed. For a system with 2-inch diameter piping, use Curve A designation values. For a system with 2.5-inch diameter piping, use Curve C designation values.

Pump Type and Variable	**Nameplate Horsepower at High Speed**					
	3	**2.5**	**2**	**1.5**	**1**	**0.75**
Curve A – WEF_{ee}	2.9	3.3	3.4	3.8	3.9	4.3
Curve A – $GPM_{ee,HS}$	74.0	66.0	66.4	61.0	56.0	56.0
Curve A – $GPM_{ee,LS}$	37.0	34.0	33.3	31.9	31.0	29.0
Curve C – WEF_{ee}	3.6	4.0	4.1	4.6	4.9	5.4
Curve C – $GPM_{ee,HS}$	102.0	90.0	89.7	78.0	70.0	73.0
Curve C – $GPM_{ee,LS}$	51.0	45.7	44.8	41.8	40.3	37.0

Variable Frequency Drive Pumps

The compliance condition is an ENERGY STAR® qualified VFD inground pool pump. Typical flow rates at high and low speeds for ENERGY STAR® VFD pool pumps are described in the table below.

Pool Pump Speed	**Flow rate**
$GPM_{ee,LS}$	$\frac{v}{hrs_{turnover} \times 60}$
$GPM_{ee,HS}$	50

where:

v = Pool volume (gallons)

$hrs_{turnover}$ = Hours for pump to cycle through pool water. If unknown, use 12 as default.

60 = Conversion factor, minutes per hour

[326] ENERGY STAR® Program Requirements Product Specification for Pool Pumps, Eligibility Criteria Version 2.0, January 2019

Typical WEF_{ee} for ENERGY STAR® self-priming VFD pool pumps are derived from the equations below based on the flow rate at each speed and pump curve type. For a system with 2-inch diameter piping, use Curve A designation values. For a system with 2.5-inch diameter piping, use Curve C designation values.

Pool Curve Type	WEF_{ee}
Curve A	$WEF_{ee} = 20.554\ e^{-0.034\ \times(0.2\times GPM_{ee,HS}+0.8\times GPM_{ee,LS})}$
Curve C	$WEF_{ee} = 27.188\ e^{-0.026\ \times(0.2\times GPM_{ee,HS}+0.8\times GPM_{ee,LS})}$

Operating Hours

Based on New York's average climate, it is assumed that a pool is in use for 4 months per year.[327] While in use, the energy efficient pump cycles through pool water at a default rate of 12 hours per turnover.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements Product Specification for Pool Pumps, Eligibility Criteria Version 2.0, January 2019
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%202.0%20Pool%20Pumps%20Specification.pdf
2. 10 CFR Appendix B to Subpart Y of Part 431 – Uniform Test Method for the Measurement of Energy Efficiency of Dedicated-Purpose Pool Pumps
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=1e172a51fbd7c0fa1753866066133e14&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1466.b
3. ENERGY STAR® Pool Pumps Version 2 and Version 3 Specification Cover Letter, April 30, 2018
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Pool%20Pumps%20Version%202%20and%20Version%203%20Specification%20Cover%20Letter.pdf

[327] It is assumed that 50% of pools are unheated and operate for 3 months per year and the other 50% of pools are heated and operate for 5 months per year, giving an average of 4 months of usage per year

4. ENERGY STAR® Pool Pump Fact Sheet, January 2018
Available from:
https://www.energystar.gov/sites/default/files/asset/document/PoolPumps_FactSheet_012318_0.pdf
5. Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps, December 2013
Available from:
https://www.energystar.gov/sites/default/files/asset/document/Pool%20Pump%20Calculator.xlsx
6. CEE℠ High Efficiency Residential Swimming Pool Initiative, Consortium for Energy Efficiency, January 2013
Available from:
https://library.cee1.org/system/files/library/9986/CEE_Res_SwimmingPoolInitiative_01Jan2013_Corrected.pdf
7. Standards Driven Market Transformation; 20 Year Multifaceted Intervention Leads to DOE Pool Pump Standard, 2016 ACEEE Summer Study on Energy Efficiency in Buildings
Available from: https://aceee.org/files/proceedings/2016/data/papers/5_761.pdf

Record of Revision

Record of Revision Number	Issue Date
6-18-20	6/30/2018
9-18-6	9/28/2018

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OTHER

GAS POOL HEATER

Measure Description

This measure covers the installation of high efficiency natural gas pool heaters in residential applications.[328] Gas-fired pool heaters are designed for heating non-potable water and employ natural gas burners. High-efficiency natural gas heaters can have thermal efficiency ratings as high as 95%. Pool heaters must have a thermal efficiency rating of 84% or greater to qualify for estimated energy savings using this measure.[329]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times (therms_{baseline} - therms_{ee})$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
therms = Annual gas consumption

Summary of Variables and Data Sources

Variable	Value	Notes
$therms_{baseline}$	364	From the annual energy consumption table below, based on a thermal efficiency rating of 82%.

[328] Similar to other measures in the NY TRM, this measure will continue to be reviewed for accuracy and for potential updates, based on up-take in programs, changes in codes and standards, and the availability of other measure-specific information.
[329] 10 CFR 430.32.(k)(1)

Variable	Value	Notes
$therms_{ee}$		Look up from energy consumption table below based on thermal efficiency rating of fuel efficient pool heater. Interpolation may be performed for pool heater efficiencies not listed.

Annual Energy Consumption[330]

Thermal Efficiency (%)	**Annual Gas Consumption ($therms_{ee}$)**
82 (baseline)	364
84	344
86	336
90	321
95	305

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a gas-fired pool heater with a thermal efficiency of 82% as mandated by federal standards.[331]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a gas-fired pool heater that has a thermal efficiency of 84% or greater.[332]

Operating Hours

Pool heater run hours are embedded in the values found in the Annual Energy Consumption table provided above. The derivation assumes a 250-kBTU/h pool heater, 26.5% of heaters equipped with a pilot light with an input rate of 1-kBTU/h, an average pilot light operating hours of 4,464 hours per year, and a distribution range of pool operational hours from 235 to 8,760 per year.

Effective Useful Life (EUL)

See Appendix P.

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330 US DOE, Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters, Chapter 7, Table 7.4.2: Annual Energy Consumption for Gas-Fired Pool Heaters. The derivation assumes a 250-kBTU/h pool heater and 26.5% of heaters equipped with a pilot light with an input rate of 1-kBTU/h.
331 10 CFR 430.32.(k)(1)
332 Compliance requirement based on SoCal Gas minimum thermal efficiency to qualify for incentive (accessed 11/27/2018)

Ancillary Fossil Fuel Savings Impacts

N / A

Ancillary Electric Savings Impacts

Analysis of baseline and high-efficiency gas pool heaters conducted using the DOE test procedure suggests that auxiliary and stand-by electric loads are slightly higher for more efficient equipment.[333] The magnitude of these effects is considered negligible relative to anticipated gas savings and electric impacts have thus been excluded from the prescribed methodology.

References

1. 10 CFR 430.32 Energy and water conservation standards and their compliance dates. Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=e2b12730e1b0fd7608318eb139d57b10&mc=true&n=pt10.3.430&r=PART&ty=HTML#se10.3.430_132
2. Department of Energy; Notice of Proposed Rulemaking Technical Support Document Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters, Chapter 7: Energy Use Characterization, November 23, 2009
Available from: https://www.regulations.gov/contentStreamer?documentId=EERE-2006-STD-0129-0170&attachmentNumber=8&contentType=pdf
3. SoCal Gas, Pool Heater List (accessed November 27, 2018)
Available from: https://www.socalgas.com/pool-heater-list

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[333] US DOE, Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters, Chapter 7, Table 7.4.2: Annual Energy Consumption for Gas-Fired Pool Heaters

COMMERCIAL AND INDUSTRIAL MEASURES

AGRICULTURAL EQUIPMENT
(place-holder)

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AGRICULTURAL EQUIPMENT – CONTROL

ENGINE BLOCK HEATER TIMER

Measure Description

This measure covers the installation of timers used to control engine block heaters on existing farm equipment engines such as tractors, skid steers, trucks, and generators. Engine block heaters are used to warm an engine prior to use and are generally used during cold weather. For convenience, engine block heaters without automation are typically left running longer than necessary. Timers limit energy consumption by pre-warming equipment only as required.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{W_{heater}}{1{,}000} \times (hrs_{baseline} - hrs_{ee}) \times days$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of engine block heaters connected to timers under the program
W_{heater} = Wattage of engine block heater under control
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
hrs = Hours of use per day
days = Days of use per year
1,000 = Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
W_{heater}		From application, if unknown use a default value of 1,000 W.[334]
$hrs_{baseline}$		From application, if unknown use a default value of 10 hrs.[335]

[334] 2018 FFA to Farm Engine Block Heater Timer Fundraiser Fact Sheet
[335] Ibid.

Variable	Value	Notes
hrs_{ee}		From application, if unknown use a default value of 2 hrs.[336]
days		From application, if unknown use a default value of 90 days.[337]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an engine block heater without a timer that is manually controlled.

Compliance Efficiency from which Incentives are Calculated

The energy efficient condition is an engine block heater controlled by a timer.

Operating Hours

Timer on hours are set by the customer. If timer set hours are unknown, assume 2 hours per day. If days of use per year are unknown, assume 90.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 2018 FFA to Farm Engine Block Heater Timer Fundraiser Fact Sheet, Focus on Energy Available from: https://focusonenergy.com/sites/default/files/inline-files/EBHT_Flyer_030418_1.pdf
2. Energy Efficiency in New York State Agriculture: Summary of Energy Efficiency Programs and Research Opportunities, NYSERDA Available from: https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Other-Technical-Reports/energy-efficiency-in-new-york-state-agriculture.pdf

[336] Ibid.
[337] Energy Efficiency in New York State Agriculture: Summary of Energy Efficiency Programs and Research Opportunities, NYSERDA, C-4

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7-13-28	7/31/2013
9-18-7	9/28/2018

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APPLIANCE

CLOTHES DRYER

Measure Description

This measure covers residential grade clothes dryers meeting the criteria established under the ENERGY STAR® Program, Version 1.1, effective May 5, 2017 installed in small commercial settings.[338] ENERGY STAR® clothes dryers have a higher combined energy factor (CEF), and save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions, improving air circulation, and improved efficiency of motors. Reduced dryer runtime is achieved through automatic termination of the dryer cycles based on temperature and moisture sensors. Clothes dryers originally qualified for the ENERGY STAR® label in May 2014. Clothes dryers that have earned this label are approximately 20% more efficient than non-qualified models.[339]

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times Cycles_{annual} \times Load \times \left(\frac{F_{elec,baseline}}{CEF_{baseline}} - \frac{F_{elec,ee}}{CEF_{ee}}\right)$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times Cycles_{annual} \times Load \times \left(\frac{F_{gas,baseline}}{CEF_{baseline}} - \frac{F_{gas,ee}}{CEF_{ee}}\right) \times \frac{3{,}412}{100{,}000}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$Cycles_{annual}$	= Number of dryer cycles per year
Load	= Average total weight (lbs) of clothes per drying cycle

[338] ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017

[339] Efficiency of ENERGY STAR® products: https://www.energystar.gov/products/appliances/clothes_dryers

baseline = Baseline condition or measure
ee = Energy efficient condition or measure
F_{elec} = Percentage of energy consumed that is derived from electricity
F_{gas} = Percentage of energy consumed that is derived from gas
CEF = Combined energy factor (lb/kWh)
hrs = Annual run hours of clothes dryer
CF = Coincidence Factor
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$Cycles_{annual}$		From application, or lookup based on efficient dryer type in table below.[340]
Load		Lookup based on efficient dryer type in table below.[341]
$F_{elec,baseline}$		Lookup based on efficient dryer type in table below.[342]
$F_{elec,ee}$		Lookup based on efficient dryer type in table below.[343]
$F_{gas,baseline}$		Lookup based on efficient dryer type in table below.[344]
$F_{gas,ee}$		Lookup based on efficient dryer type in table below.[345]
$CEF_{baseline}$		Lookup based on efficient dryer type in table below.[346]
CEF_{ee}		Lookup based on efficient dryer type in table below.[347]
hrs		From application, or lookup based on efficient dryer type in table below.[348]
CF	0.042	

Key Variables Lookup Table

Variable	Dryer Type				
	Vented Gas Dryer	*Ventless or Vented Electric, Standard ≥ 4.4 ft³*	*Ventless or Vented Electric, Compact (120V) < 4.4 ft³*	*Vented Electric, Compact (240V) < 4.4 ft³*	*Ventless Electric, Compact (240V) < 4.4 ft³*
$Cycles_{annual}$	283	283	283	283	283
Load	8.45	8.45	3.00	3.00	3.00

[340] Savings calculator for ENERGY STAR® Qualified Appliances (accessed 10/18/2017)
[341] Ibid.
[342] ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017
[343] Ibid.
[344] Ibid.
[345] Ibid.
[346] 10 CFR 430.32 (h)(3)
[347] ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017
[348] Savings calculator for ENERGY STAR® Qualified Appliances (accessed 10/18/2017)

Variable	Dryer Type				
	Vented Gas Dryer	*Ventless or Vented Electric, Standard ≥ 4.4 ft³*	*Ventless or Vented Electric, Compact (120V) < 4.4 ft³*	*Vented Electric, Compact (240V) < 4.4 ft³*	*Ventless Electric, Compact (240V) < 4.4 ft³*
$F_{elec,baseline}$	0.05	1.00	1.00	1.00	1.00
$F_{elec,ee}$	0.05	1.00	1.00	1.00	1.00
$F_{gas,baseline}$	0.95	0.00	0.00	0.00	0.00
$F_{gas,ee}$	0.95	0.00	0.00	0.00	0.00
$CEF_{baseline}$	3.30	3.73	3.61	3.27	2.55
CEF_{ee}	3.48	3.93	3.80	3.45	2.68
hrs	290	290	290	290	290

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.042.[349]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard efficiency, residential grade clothes dryer with operating specifications as defined in the Key Variables Lookup Table above.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a residential grade clothes dryer appearing on the ENERGY STAR® qualified products list.

Operating Hours

Operating hours for residential clothes dryers are provided in the Key Variables Lookup Table above. In the absence of justifiable default operating characteristics for residential grade clothes dryers installed in small commercial facilities, residential values are assumed.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

A clothes dryer releases heat to the surrounding environment. Conventional vented dryers also vent air outside the building. The associated HVAC impact of dryers depends upon a number of variables including climate and placement of a dryer (i.e., in a conditioned or unconditioned space).

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[349] Based on Central Maine Power Company "Residential End-Use Metering Project", 1988. Using 8,760 data for electric clothes dryers, calculating the CF according to the PJM peak definition. This study is not publicly available, but is referenced by the Pennsylvania Technical Reference Manual, State of Pennsylvania, 2016. http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

It is an area of ongoing research.[350] These impacts are excluded from the methodology prescribed herein until they can be quantified and substantiated through independent research.

Ancillary Electric Savings Impacts

See Ancillary Fossil Fuel Savings Impacts section above.

References

1. ENERGY STAR® Program Requirements Product Specification for Clothes Dryers, Eligibility Criteria Version 1.1, May 2017
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria.pdf
2. Savings calculator for ENERGY STAR® Qualified Appliances
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
3. 10 CFR 430.32 Energy and water conservation standards and their compliance dates.
   Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
4. Pennsylvania Technical Reference Manual, State of Pennsylvania, 2016.
   Available from: http://www.puc.pa.gov/pcdocs/1370278.docx
5. ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryers, November 2011
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

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[350] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryers, November 2011

COMBINATION OVENS

Measure Description

This measure covers the installation of ENERGY STAR® qualified gas or electric commercial combination ovens.[351] Though not eligible for ENERGY STAR® qualifications, electric combination ovens with capacities of 21 pans or greater aligning with Food Service Technology Center (FSTC) assumptions for energy efficient products per the compliance efficiencies section below are also included in the measure.[352] A combination oven combines the function of hot air convection, saturated and superheating steam heating, and combination convection/steam mode for moist heating. The oven is used for steaming, baking, roasting, re-thermalizing, and proofing of various food products. High efficiency boiler-less combination ovens use nearly half as much water as typical boiler-based combination ovens.[353]

A combination oven can also be referred to as a combi, combo, or combination oven/steamer. Combination ovens come in a range of sizes based on their capacity to accommodate 12 x 20 x 2 1/2 inch hotel pans. This measure includes half size and full size combination ovens. Measure calculations are based on oven pan capacity of full size, 2 1/2 inch hotel pans.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Equipment Only)

$$\Delta kWh = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle,c} + \Delta BTU_{idle,s} + \Delta BTU_{cooking,c} + \Delta BTU_{cooking,s}\right)}{3{,}412}$$

Peak Coincident Demand Savings (Electric Equipment Only)

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

Annual Gas Energy Savings (Gas Equipment Only)

$$\Delta therms = units \times days \times \frac{\left(\Delta BTU_{preheat} + \Delta BTU_{idle,c} + \Delta BTU_{idle,s} + \Delta BTU_{cooking,c} + \Delta BTU_{cooking,s}\right)}{100{,}000}$$

where:

$$\Delta BTU_{preheat} = N_{preheat} \times \left(BTU_{preheat,baseline} - BTU_{preheat,ee}\right)$$

$$\Delta BTU_{idle,c} = \left[BTUh_{idle,c,baseline} \times \left(hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{c,baseline}}\right) - BTUh_{idle,c,ee} \times \left(hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{c,ee}}\right)\right] \times (1 - F_s)$$

[351] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2, March 2015
[352] Food Service Technology Center, Qualified Combination Ovens, February 2018
[353] Food Service Technology Center, Combination Ovens, Save Water (accessed 3/15/2018)

$$\Delta BTU_{idle,s} = \left[BTU/h_{idle,s,baseline} \times \left(hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{s,baseline}}\right) - BTU/h_{idle,s,ee} \times \left(hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{s,ee}}\right)\right] \times F_s$$

$$\Delta BTU_{cooking,c} = lbs \times Q_{food,c} \times \left(\frac{1}{Eff_{c,baseline}} - \frac{1}{Eff_{c,ee}}\right) \times (1 - F_s)$$

$$\Delta BTU_{cooking,s} = lbs \times Q_{food,s} \times \left(\frac{1}{Eff_{s,baseline}} - \frac{1}{Eff_{s,ee}}\right) \times F_s$$

NOTE: $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms can be calculated per the equations above using any combination of actual qualifying equipment specifications and assumed values as defined in the Baseline Efficiencies, Compliance Efficiency and Operating Hours sections below, or looked up from the Default Values table below.

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
$\Delta BTU_{preheat}$	= Daily preheat energy savings
ΔBTU_{idle}	= Daily idle energy savings
$\Delta BTU_{cooking}$	= Daily cooking energy savings
units	= Number of measures installed under the program
days	= Operating days per year
hrs	= Daily operating hours
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
c	= Convection mode
s	= Steam mode
$BTU_{preheat}$	= Equipment preheat energy (BTU)
$N_{preheat}$	= Number of preheats per day
$hrs_{preheat}$	= Preheat duration (hours)
BTU/h_{idle}	= Equipment idle energy rate (BTU/h)
(lbs/hr)	= Equipment production capacity (lbs/hr)
lbs	= Total daily food production
Q_{food}	= Heat to food (BTU/lb)
Eff	= Equipment convection/steam mode cooking efficiency
F_s	= Steam mode time factor
CF	= Coincidence factor
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta BTU_{preheat}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{idle,c}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{idle,s}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking,c}$		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking,s}$		Calculate based on calculations above or look up in Default Values table below.
days		From application or look up based on facility type in Operating Hours section below.
hrs		From application or look up based on facility type in Operating Hours section below.
$N_{preheat}$	1	Pacific Gas and Eletric. [354]
$BTU_{preheat,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU_{preheat,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$BTU/h_{idle,c,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU/h_{idle,s,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU/h_{idle,c,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$BTU/h_{idle,s,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$hrs_{preheat}$	0.25	Pacific Gas and Eletric. [355]
$(lbs/hr)_{c,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$(lbs/hr)_{s,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$(lbs/hr)_{c,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below
$(lbs/hr)_{s,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below
lbs	< 15 Pans: 200 15-28 Pans: 250 > 28 Pans: 400	From application or use values provided[356]

[354] PG&E Work Paper PGECOFST100 Revision 6, Table 8, pg. 13
[355] Ibid.
[356] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)

Variable	Value	Notes
$Q_{food,c}$	250	Convection mode heat to food (BTU/lb) [357]
$Q_{food,s}$	105	Steam mode heat to food (BTU/lb) [358]
$Eff_{c,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$Eff_{s,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$Eff_{c,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$Eff_{s,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
F_s	0.50	ENERGY STAR®.[359]
CF	0.9	

<u>Default Values</u>

The table below contains values and simplified calculations for $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms that may be used in the formulation of estimated savings in lieu of utilizing the calculations prescribed above for these terms. These values were established by performing those calculations using assumed values from the Common Variables, Baseline Efficiencies and Compliance Efficiency sections below.

Equipment	$\Delta BTU_{preheat}$	$\Delta BTU/h_{idle,c}$	$\Delta BTU/h_{idle,s}$	$\Delta BTU_{cooking,c}$	$\Delta BTU_{cooking,s}$
Combi Electric Oven, < 15 Pans[360]	5,118	36 x hrs -1,986	5,612 x hrs - 15,647	1,827	2,338
Combi Electric Oven, 15 - 20 Pans[361]	5,971	309 x hrs -1,481	9,227 x hrs - 14,899	2,284	2,922
Combi Electric Oven, 21 - 28 Pans	5,971	2,133 x hrs - 7,997	11,089 x hrs - 38,314	3,434	6,563
Combi Electric Oven, > 28 Pans	8,974	2,133 x hrs - 5,162	15,354 x hrs - 38,933	5,495	10,500
Combi Gas Oven, < 15 Pans[362]	5,000	911 x hrs -1,641	5,073 x hrs - 10,835	3,434	1,313
Combi Gas Oven, 15 - 28 Pans[363]	6,000	1,182 x hrs - 2,942	7,026 x hrs - 16,307	4,293	1,642
Combi Gas Oven, 29 - 30 Pans[364]	8,000	432 x hrs -1,862	6,026 x hrs - 16,057	4,293	1,642
Combi Gas Oven, > 30 Pans[365]	8,000	788 x hrs -1,030	14,395 x hrs - 18,555	6,868	2,627

[357] Ibid.
[358] Ibid.
[359] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[360] Assumes 10 pans
[361] Assumes 20 pans
[362] Assumes 10 pans
[363] Assumes 20 pans
[364] Assumes 30 pans
[365] Assumes 40 pans

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[366]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a combination oven as defined in the Measure Description section above with operating characteristics per the table below. Values are as reported from referenced ENERGY STAR® Commercial Food Service Calculator[367] unless otherwise noted. Preheat energy rates and all values for electric combi-ovens with capacities greater than 21 pans are reported from referenced FSTC calculators.

Equipment	$BTU_{preheat, baseline}$ (BTU)	$BTU/h_{idle, c,baseline}$ (BTU/h)	$BTU/h_{idle, s,baseline}$ (BTU/h)	$(lbs/hr)_{c,baseline}$	$(lbs/hr)_{s,baseline}$	$Eff_{c,baseline}$	$Eff_{s,baseline}$
Combi Electric Oven, < 15 Pans	10,236[368]	4,504	17,947	79	126	0.72	0.49
Combi Electric Oven, 15 - 20 Pans	12,795[369]	7,779	29,719	166	295	0.72	0.49
Combi Electric Oven, 21 - 28 Pans[370]	12,795	12,795	42,650	100	150	0.65	0.40
Combi Electric Oven, > 28 Pans[371]	19,210	17,913	61,416	275	350	0.65	0.40
Combi Gas Oven, < 15 Pans	18,000[372]	8,747	18,656	125	195	0.52	0.39
Combi Gas Oven, 15 - 28 Pans	22,000[373]	10,788	24,562	176	211	0.52	0.39
Combi Gas Oven, 29 - 30 Pans	32,000[374]	10,788	24,562	176	211	0.52	0.39
Combi Gas Oven, > 30 Pans	32,000[375]	13,000	43,300	392	579	0.52	0.39

Compliance Efficiency from which Incentives are Calculated

The compliance condition is ENERGY STAR® food service equipment as defined in the Measure Description section above. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the table below. Values are as reported from the referenced ENERGY STAR® Commercial Food Service Calculator[376], unless otherwise noted.

[366] PG&E Work Paper PGECOFST100 Revision 6, Table 8, pg. 13
[367] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[368] Food Service Technology Center, Electric Combination Oven Life-Cycle Cost Calculator
[369] Ibid.
[370] Ibid.
[371] Ibid.
[372] Food Service Technology Center, Gas Combination Oven Life-Cycle Cost Calculator
[373] Ibid.
[374] Ibid.
[375] Ibid.
[376] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)

Preheat energy rates and all values for electric combi ovens with capacity greater than 21 pans are reported from referenced FSTC calculators.

Equipment	$BTU_{preheat, ee}$ (BTU)	$BTU/h_{idle, c,ee}$ (BTU/h)	$BTU/h_{idle, s,ee}$ (BTU/h)	(lbs/hr) c,ee	(lbs/hr) s,ee	Eff c,ee	Eff s,ee
Combi Electric Oven, < 15 Pans	5,118[377]	273 x no. pans + 1,702	454 x no. pans + 2,184	119	177	0.76	0.55
Combi Electric Oven, 15 - 20 Pans	6,824[378]	273 x no. pans + 1,702	454 x no. pans + 2,184	201	349	0.76	0.55
Combi Electric Oven, 21 - 28 Pans[379]	6,824	8,530	20,472	125	200	0.70	0.50
Combi Electric Oven, > 28 Pans[380]	10,236	13,648	30,708	325	400	0.70	0.50
Combi Gas Oven, < 15 Pans	13,000[381]	150 x no. pans + 5,425	200 x no. pans + 6,511	124	172	0.56	0.41
Combi Gas Oven, 15 - 28 Pans	16,000[382]	150 x no. pans + 5,425	200 x no. pans + 6,511	210	277	0.56	0.41
Combi Gas Oven, 29 - 30 Pans	24,000[383]	150 x no. pans + 5,425	200 x no. pans + 6,511	210	277	0.56	0.41
Combi Gas Oven, > 30 Pans	24,000[384]	150 x no. pans + 5,425	200 x no. pans + 6,511	394	640	0.56	0.41

Operating Hours

Equipment operating hours per day and days per year shall be taken from the application if known. Default operating hours per day and days per year are provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[385]

Facility Type	Hours/Day	Days/Year
Community College	11	283
Fast Food	14	363
Full Service Restaurant	12	321
Grocery	12	365
Hospital	11	365
Hotel	20	365
Miscellaneous	9	325
Motel	20	365
Primary School	5	180

377 Food Service Technology Center, Electric Combination Oven Life-Cycle Cost Calculator
378 Ibid.
379 Ibid.
380 Ibid.
381 Food Service Technology Center, Gas Combination Oven Life-Cycle Cost Calculator
382 Ibid.
383 Ibid.
384 Ibid.
385 California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E

Facility Type	Hours/Day	Days/Year
Secondary School	8	180
Small Office	12	250
University	11	283

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the condition space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

Ancillary Electric Savings Impacts

More efficient food service equipment rejects less heat into the condition space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

References

1. ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 2.2, March 2015.
   Available from:
   https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf
2. Food Service Technology Center, Qualified Combination Ovens, February 2018
   Available from: https://fishnick.com/saveenergy/rebates/combis.pdf
3. Food Service Technology Center, Combination Ovens, Save Water (accessed March 15, 2018)
   Available from: https://fishnick.com/savewater/appliances/combinationovens/
4. Pacific Gas & Electric Company, Work Paper PGECOFST100 Commercial Combination Oven, Revision 6, August 2016.
5. ENERGY STAR® Commercial Food Service Calculator (accessed February 26, 2018)
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator_0.xlsx
6. Food Service Technology Center: Electric Combination Oven Life-Cycle Cost Calculator
   Available from: https://caenergywise.com/calculators/electric-combination-ovens/#calc
7. Food Service Technology Center: Gas Combination Oven Life-Cycle Cost Calculator
   Available from: https://caenergywise.com/calculators/natural-gas-combination-

ovens/#calc

8. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014.
Available from: http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

Record of Revision

Record of Revision Number	Issue Date
3-18-19	3/29/2018

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Insulated Holding Cabinets

Measure Description

This measure covers the installation of ENERGY STAR® qualified electric commercial hot food holding cabinets.[386] A food holding cabinet is a fully enclosed compartment designed to maintain the temperature of hot food that has been cooked in a separate appliance. Half-size, full-size and large-size holding cabinets are included in this measure. Half-size holding cabinets are defined as any holding cabinet with an internal measured volume of less than $15ft^3$. Full-size holding cabinets are defined as any holding cabinet with an internal measured volume of greater than or equal to $15ft^3$ and less than or equal to $28ft^3$. Large-size holding cabinets are defined as any holding cabinet with an internal measure volume of greater than $28ft^3$. This measure does not include cook-and-hold or re-therm equipment.[387]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hrs \times days \times \frac{\Delta W_{idle}}{1{,}000}$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

$$\Delta W_{idle} = W_{idle,baseline} - W_{idle,ee}$$

NOTE: ΔW_{idle} term can be calculated per the equation above using actual qualifying equipment specifications or looked up from the Default Values table below.

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
ΔW_{idle}	= Daily idle energy savings
units	= Number of measures installed under the program
hrs	= Daily operating hours

[386] ENERGY STAR® Program Requirements for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0, July 2011

[387] PG&E Work Paper PGECOFST105 Revision 5, pg. 1

days = Operating days per year
v = Volume of holding cabinet (ft^3)
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
W_{idle} = Equipment idle energy rate by volume (W)
CF = Coincidence factor
1,000 = Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
ΔW_{idle}		Calculate based on calculations above or look up in Default Values table below.
days		From application or look up based on facility type in Operating Hours section below.
hrs		From application or look up based on facility type in Operating Hours section below.
v	Large-Size: 35 Full-Size: 25 Half-Size: 10	From application or use default values provided.[388]
$W_{idle,baseline}$	40v	Equipment idle energy rate by volume (W).[389]
$W_{idle,ee}$	Large-Size: 3.8v + 203.5 Full-Size: 2v + 254 Half-Size: 21.5v	From application or use default value provided.[390]
CF	0.9	

<u>Default Values</u>
The table below contains ΔW_{idle} values that may be used in the formulation of estimated savings in lieu of utilizing the calculation prescribed above for this term. These values were established by performing that calculation using default values from the Summary of Variables and Data Sources above.

Equipment	ΔW_{idle}
Insulated Holding Cabinet, Large-Size	1,064
Insulated Holding Cabinet, Full-Size	696
Insulated Holding Cabinet, Half-Size	185

[388] PG&E Work Paper PGECOFST105 Revision 5, Table 6, pg. 5
[389] ENERGY STAR® Program Requirements for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0, July 2011, where v is holding cabinet volume (ft^3)
[390] Ibid, where v is holding cabinet volume (ft^3)

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[391]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an insulated holding cabinet as defined in the Measure Description above with operating characteristics per the Summary of Variables and Data Sources table above.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is ENERGY STAR® food service equipment as defined in the Measure Description section above. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the Summary of Variables and Data Sources table above.

Operating Hours

Equipment operating hours per day and days per year shall be taken from the application if known. Default operating hours per day and days per year are provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[392]

Facility Type	hours/day	days/year
Community College	11	283
Fast Food Restaurant	14	363
Full Service Restaurant	12	321
Grocery	12	365
Hospital	11	365
Hotel	20	365
Miscellaneous	9	325
Motel	20	365
Primary School	5	180
Secondary School	8	180
Office	12	250
University	11	283

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been found to date that would allow quantification of these impacts. Until

[391] PG&E Work Paper PGECOFST105 Revision 5, pg. 7
[392] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E

additional information is available, these impacts are excluded from the prescribed formulation of savings.

Ancillary Electric Savings Impacts

More efficient food service equipment rejects less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been found to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

References

1. ENERGY STAR® Program Requirements for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0, July 2011.
   Available from:
   https://www.energystar.gov/sites/default/files/specs/private/Commercial_HFHC_Program_Requirements_2.0.pdf
2. Pacific Gas & Electric Company, Work Paper PGECOFST105 Insulated Holding Cabinet-Electric, Revision 5, July 2016.
3. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014.
   Available from: http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

Record of Revision

Record of Revision Number	Issue Date
3-18-20	3/29/2018

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OVENS, STEAMERS, FRYERS AND GRIDDLES

Measure Description

This measure covers the installation of ENERGY STAR® qualified commercial kitchen equipment that meet the descriptions below. Unless otherwise noted, presented baseline, compliance, and default values are determined from ENERGY STAR® Commercial Food Service Equipment Calculator.[393]

- Convection Ovens[394] - This measure includes gas and electric commercial convection ovens. A convection oven forces hot dry air over the surface of a food product. A full size convection oven can accommodate standard full size sheet pans measuring 18 x 26 x 1 inch. A half size convection oven can accommodate half size sheet pans measuring 18 x 13 x 1 inch. Though not eligible for ENERGY STAR® qualification, this measure includes half size gas convection ovens. Half size gas convection ovens must have an idle rate of 8,000 BTU/h or less, per assumed efficiency of qualified equipment by the Food Service Technology Center (FSTC).[395]
- Rack Ovens[396] - This measure includes gas commercial rack ovens. A rack oven is a high capacity oven in which a rack is wheeled into the oven and can be rotated during the baking process. Rack ovens range in capacity from mini rack ovens to quadruple rack ovens. Single and double rack ovens are included in this measure.
- Steamers[397] - This measure includes gas and electric commercial steamers, also known as compartment steamers. A steamer is a device that contains one or more food steaming compartments in which the energy in the steam is transferred to the food by direct contact. To calculate the savings for this measure, the number of pans must be known. Countertop, wall-mounted, and floor models mounted on a stand, pedestal, or cabinet-style base are included. Commercial steamer microwave ovens are not included in this measure.
- Fryers[398] - This measure includes gas and electric commercial deep-fat fryers. A deep-fat fryer is an appliance in which oils are placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid rather than by the bottom of the vessel. Depending on the fryer type, heat is delivered to the cooking fluid by means of an immersed electric element or band-wrapped vessel (electric fryers), or by heat transfer from gas burners through either the walls of the fryer or through tubes passing through the cooking fluid (gas fryers). Standard fryers and large vat fryers are included in this measure.
- Griddles[399] - This measure includes single-sided gas and electric commercial griddles. A single-sided commercial griddle is a commercial appliance designed for cooking food in

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393 ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)

394 ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 2.2., March 2015

395 Food Service Technology Center, Qualified Convection Ovens, February 2018

396 ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria, Version 2.2., March 2015

397 ENREGY STAR® Program Requirements for Commercial Steam Cookers, Eligibility Criteria Version 1.2, August 2003

398 ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 3.0. October 2016

399 ENERGY STAR® Program Requirements for Commercial Griddles, Eligibility Criteria Version 1.2, January 2011

oil or its own juices by direct contact with either a flat, smooth, hot surface or a hot channeled cooking surface where plate temperature is thermostatically controlled. To calculate the energy savings in this measure, the griddle dimensions must be known. This measure does not include double-sided gas or electric commercial griddles.

- Gas Conveyor Ovens - Though not eligible for ENERGY STAR® qualification, this measure additionally covers the installation of energy efficient gas conveyor ovens. Conveyor ovens cook food by carrying it on a moving belt through a heated chamber. Qualifying conveyor ovens have baking efficiencies greater than or equal to 42% and idle energy rates less than or equal to 57,000 BTU/h, per assumed efficiency of qualified equipment by the Food Service Technology Center (FSTC).[400]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Equipment Only)

$$\Delta kWh = units \times days \times \frac{(\Delta BTU_{preheat} + \Delta BTU_{idle} + \Delta BTU_{cooking})}{3{,}412}$$

Peak Coincident Demand Savings (Electric Equipment Only)

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

Annual Gas Energy Savings (Gas Equipment Only)

$$\Delta therms = units \times days \times \frac{(\Delta BTU_{preheat} + \Delta BTU_{idle} + \Delta BTU_{cooking})}{100{,}000}$$

where:

$$\Delta BTU_{preheat} = N_{preheat} \times (BTU_{preheat,baseline} - BTU_{preheat,ee})$$

$$\Delta BTU_{idle} = BTU/h_{idle,baseline} \times \left[hrs - N_{preheat} \times hrs_{preheat} - \left(\frac{lbs}{(lbs/hr)_{baseline}}\right)\right] - BTU/h_{idle,ee} \times \left[hrs - N_{preheat} \times hrs_{preheat} - \left(\frac{lbs}{(lbs/hr)_{ee}}\right)\right]$$

$$\Delta BTU_{cooking} = lbs \times Q_{food} \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right)$$

NOTE: $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms can be calculated per the equations above using either actual qualifying equipment specs or default values as defined in the Common

[400] Food Service Technology Center, Qualified Conveyor Ovens, February 2018

Variables, Baseline Efficiencies, Compliance Efficiency and Operating Hours sections below, or looked up from the Default Values table below.

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
$\Delta BTU_{preheat}$ = Daily preheat energy savings
ΔBTU_{idle} = Daily idle energy savings
$\Delta BTU_{cooking}$ = Daily cooking energy savings
units = Number of measures installed under the program
days = Operating days per year
hrs = Daily operating hours
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
$BTU_{preheat}$ = Equipment preheat energy (BTU)
$N_{preheat}$ = Number of preheats per day
$hrs_{preheat}$ = Preheat duration (hours)
BTU/h_{idle} = Equipment idle energy rate (BTU/h)
(lbs/hr) = Equipment production capacity (lbs/hr)
lbs = Total daily food production
Q_{food} = Heat to food (BTU/lb)
Eff = Equipment convection/steam mode cooking efficiency
CF = Coincidence factor
3,412 = Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
$\Delta BTU_{preheat}$		Calculate based on calculations above or look up in Default Values table below.
ΔBTU_{idle}		Calculate based on calculations above or look up in Default Values table below.
$\Delta BTU_{cooking}$		Calculate based on calculations above or look up in Default Values table below.
days		From application or look up based on facility type in Operating Hours section below.
hrs		From application or look up based on facility type in Operating Hours section below.
$N_{preheat}$	1	Pacific Gas and Eletric. [401]
$BTU_{preheat,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU_{preheat,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.

[401] Shared assumption from all PG&E Work Papers referenced in this measure

Variable	Value	Notes
$BTU/h_{idle,baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$BTU/h_{idle,ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
$hrs_{preheat}$		Look up based on qualifying equipment type in Common Variables table below.
$(lbs/hr)_{baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
$(lbs/hr)_{ee}$		From application or look up based on qualifying equipment type in Compliance Efficiency section below
Lbs		From application or look up based on qualifying equipment type in Common Variables table below.
Q_{food}		Look up based on qualifying equipment type in Common Variables table below.
$Eff_{baseline}$		Look up based on qualifying equipment type in Baseline Efficiencies section below.
Eff_{ee}		From application or look up based on qualifying equipment type in Compliance Efficiency section below.
CF	0.9	

Default Values

The table below contains values and simplified calculations for $\Delta BTU_{preheat}$, ΔBTU_{idle} and $\Delta BTU_{cooking}$ terms that may be used in the formulation of estimated savings in lieu of utilizing the calculations prescribed above for these terms. These values were established by performing those calculations using assumed values from the Common Variables, Baseline Efficiencies and Compliance Efficiency sections below.

Equipment	$\Delta BTU_{preheat}$	ΔBTU_{idle}	$\Delta BTU_{cooking}$
Convection Oven, Electric, Full Size	1,706	1,365 x hrs - 1,858	3,250
Convection Oven, Electric, Half Size	341	102 x hrs - 1,011	1,553
Convection Oven, Gas, Full Size	8,000	3,100 x hrs - 5,014	2,470
Convection Oven, Gas, Half Size	5,500	3,500 x hrs - 12,087	27,778
Conveyor Oven, Gas	17,000	13,000 x hrs - 55,144	124,405
Rack Oven, Gas, Double Rack	15,000	35,000 x hrs – 179,550	397,692
Rack Oven, Gas, Single Rack	6,000	18,000 x hrs - 89,017	176,250
Steamer, Electric[402]	0	14,581 x hrs – 11,229	19,385
Steamer, Gas[403]	11,000	27,378 x hrs – 24,643	42,368
Fryer, Electric, Standard	2,047	1,365 x hrs - 3,941	10,988
Fryer, Electric, Large Vat	1,194	853 x hrs - 2,005	15,268
Fryer, Gas, Standard	4,500	5,000 x hrs - 15,481	73,286
Fryer, Gas, Large Vat	5,000	4,000 x hrs - 8,636	73,286

[402] Assumes 6 pans
[403] Assumes 6 pans

Equipment	$\Delta BTU_{preheat}$	ΔBTU_{idle}	$\Delta BTU_{cooking}$
Griddle, Electric[404]	6,834	1,638 x hrs - 7,451	5,220
Griddle, Gas[405]	6,000	5,100 x hrs - 49,875	23,438

Common Variables[406]

Equipment	Value		
	$hrs_{preheat}$	lbs	Q_{food} (BTU/lb)
Convection Oven, Electric, Full Size	0.25[407]	100	250
Convection Oven, Electric, Half Size	0.25[408]	100	250
Convection Oven, Gas, Full Size	0.25[409]	100	250
Convection Oven, Gas, Half Size	0.25[410]	100	250
Conveyor Oven, Gas	0.25[411]	190	250
Rack Oven, Gas, Double Rack	0.33[412]	1,200[413]	235
Rack Oven, Gas, Single Rack	0.33[414]	600	235
Steamer, Electric	0.25[415]	100	105
Steamer, Gas	0.25[416]	100	105
Fryer, Electric, Standard	0.25[417]	150	570
Fryer, Electric, Large Vat	0.25[418]	150	570
Fryer, Gas, Standard	0.25[419]	150	570
Fryer, Gas, Large Vat	0.25[420]	150	570
Griddle, Electric	0.25[421]	100	475
Griddle, Gas	0.25[422]	100	475

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[423]

404 Assumes 3-foot griddle width, 2-foot griddle depth
405 Assumes 3-foot griddle width, 2-foot griddle depth
406 ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018), unless otherwise noted
407 PG&E Work Paper PGECOFST101 Revision 6, Table 10, pg. 15
408 PG&E Work Paper PGECOFST101 Revision 6, Table 9, pg. 14
409 PG&E Work Paper PGECOFST101 Revision 6, Table 13, pg. 18
410 PG&E Work Paper PGECOFST101 Revision 6, Table 12, pg. 18
411 PG&E Work Paper PGECOFST117 Revision 5, Table 9, pg. 11-12, where 1 pizza equals 0.76 lbs
412 PG&E Work Paper PGECOFST109 Revision 6, Table 7, pg. 12
413 Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
414 PG&E Work Paper PGECOFST109 Revision 6, Table 7, pg. 12
415 PG&E Work Paper PGECOFST104 Revision 6, Table 11, pg. 13
416 PG&E Work Paper PGECOFST104 Revision 6, Table 12, pg. 15
417 PG&E Work Paper PGECOFST102 Revision 6, Table 10, pg. 7
418 PG&E Work Paper PGECOFST102 Revision 6, Table 10, pg. 7
419 PG&E Work Paper PGECOFST102 Revision 6, Table 11, pg. 10
420 PG&E Work Paper PGECOFST102 Revision 6, Table 11, pg. 10
421 PG&E Work Paper PGECOFST103 Revision 7, Table 8, pg. 6
422 PG&E Work Paper PGECOFST103 Revision 7, Table 9, pg. 9
423 Shared assumption from all PG&E Work Papers referenced in this measure

Baseline Efficiencies from which Savings are Calculated

The baseline condition is food service equipment as defined in the Measure Description above with operating characteristics per the table below. Values are as reported from referenced ENERGY STAR® Commercial Food Service Equipment Calculator unless otherwise noted.[424] Preheat energy and all values for half size gas convection ovens and conveyor ovens are reported from referenced FSTC sources.

Equipment	$BTU_{preheat,baseline}$ (BTU)	$BTU/h_{idle,baseline}$ (BTU/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$
Convection Oven, Electric, Full Size	5,118[425]	6,824	90	0.65
Convection Oven, Electric, Half Size	3,412[426]	3,514	45	0.68
Convection Oven, Gas, Full Size	19,000[427]	15,100	83	0.44
Convection Oven, Gas, Half Size[428]	13,000	12,000	45	0.30
Conveyor Oven, Gas[429]	35,000	70,000	114	0.20
Rack Oven, Gas, Double Rack	100,000[430]	65,000	250	0.30
Rack Oven, Gas, Single Rack	50,000[431]	43,000	130	0.30
Steamer, Electric	5,118[432]	2,047 + 3,767 x no. pans[433]	23.3 x no. pans	0.26
Steamer, Gas	20,000[434]	9,000 + 6,524 x no. pans[435]	23.3 x no. pans	0.15
Fryer, Electric, Standard	8,189[436]	4,094	65	0.75
Fryer, Electric, Large Vat	10,577[437]	4,606	100	0.70
Fryer, Gas, Standard	18,500[438]	14,000	60	0.35
Fryer, Gas, Large Vat	27,000[439]	16,000	100	0.35
Griddle, Electric	2,275 x griddle area[440]	1,365 x griddle area	5.83 x griddle area	0.65
Griddle, Gas	3,500 x griddle area[441]	3,500 x griddle area	4.17 x griddle area	0.32

[424] ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
[425] Food Service Technology Center: Electric Convection Oven Life-Cycle Cost Calculator
[426] Food Service Technology Center: Electric Convection Oven Life-Cycle Cost Calculator
[427] Food Service Technology Center: Gas Convection Oven Life-Cycle Cost Calculator
[428] Food Service Technology Center: Gas Convection Oven Life-Cycle Cost Calculator
[429] Food Service Technology Center: Gas Conveyor Oven Life-Cycle Cost Calculator, where 1 pizza equals 0.76 lbs
[430] Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
[431] Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
[432] Food Service Technology Center: Electric Steamer Life-Cycle Cost Calculator
[433] Represents energy rate when steamers are in idle mode and in constant steam mode: $(1 – Ts)*BTU/h_{idle,baseline}+ Ts*(lb/hr)_{baseline}*Q_{food}/Eff_{baseline}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,baseline}$ = 3,412 BTU/h for baseline electric steamers
[434] Food Service Technology Center: Gas Steamer Life-Cycle Cost Calculator
[435] Represents energy rate when steams are in idle mode and in constant steam mode: $(1 – Ts)*BTU/h_{idle,baseline}+ Ts*(lb/hr)_{baseline}*Q_{food}/Eff_{baseline}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,baseline}$ = 15,000 BTU/h for baseline gas steamers
[436] Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator
[437] Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator
[438] Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator
[439] Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator
[440] Food Service Technology Center: Electric Griddle Life-Cycle Cost Calculator
[441] Food Service Technology Center: Gas Griddle Life-Cycle Cost Calculator

Compliance Efficiency from which Incentives are Calculated

The compliance condition is ENERGY STAR® food service equipment or, in the case of conveyor ovens and half size gas convection ovens, equipment aligning with FSTC assumptions for energy efficient products meeting the minimum performance specifications listed in the table below. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the table below. Values are as reported from the ENERGY STAR® Commercial Food Service Equipment Calculator, unless otherwise noted.[442] Preheat energy and all values for half size gas convection ovens and conveyor ovens are reported from referenced FSTC sources.

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	$(lbs/hr)_{ee}$	Eff_{ee}
Convection Oven, Electric, Full Size	3,412[443]	5,459	90	0.71
Convection Oven, Electric, Half Size	3,071[444]	3,412	50	0.71
Convection Oven, Gas, Full Size	11,000[445]	12,000	86	0.46
Convection Oven, Gas, Half Size[446]	7,500	8,500	55	0.45
Conveyor Oven, Gas[447]	18,000	57,000	167	0.42
Rack Oven, Gas, Double Rack	85,000[448]	30,000	250	0.52
Rack Oven, Gas, Single Rack	44,000[449]	25,000	130	0.48
Steamer, Electric	5,118[450]	1,678 x no. pans*[451]	16.7 x no. pans	0.50
Steamer, Gas	9,000[452]	3,463 x no. pans*[453]	20.8 x no. pans	0.38
Fryer, Electric, Standard	6,483[454]	2,730	70	0.83
Fryer, Electric, Large Vat	9,383[455]	3,753	110	0.80
Fryer, Gas, Standard	16,000[456]	9,000	65	0.50
Fryer, Gas, Large Vat	22,000[457]	12,000	110	0.50

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442 ENERGY STAR® Commercial Food Service Equipment Calculator (accessed 2/26/2018)
443 Food Service Technology Center: Electric Convection Oven Life-Cycle Cost Calculator
444 Food Service Technology Center: Electric Convection Oven Life-Cycle Cost Calculator
445 Food Service Technology Center: Gas Convection Oven Life-Cycle Cost Calculator
446 Food Service Technology Center: Gas Convection Oven Life-Cycle Cost Calculator
447 Food Service Technology Center: Gas Conveyor Oven Life-Cycle Cost Calculator, where 1 pizza equals 0.76 lbs
448 Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
449 Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator
450 Food Service Technology Center: Electric Steamer Life-Cycle Cost Calculator
451 Represents energy rate when steamer are in idle mode and in constant steam mode: $(1 – Ts)*BTU/h_{idle,ee} + Ts*(lb/hr/pan)*Q_{food}/Eff_{ee}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,ee}$ = 455 BTU/h x no. of pans for compliance electric steamers
452 Food Service Technology Center: Gas Steamer Life-Cycle Cost Calculator
453 Represents energy rate when steamers are in idle mode and in constant steam mode: $(1 – Ts)*BTU/h_{idle,ee} + Ts*(lb/hr/pan)*Q_{food}/Eff_{ee}$, where Ts (time in constant steam mode) = 40% of non-cook time and $BTU/h_{idle,ee}$ = 2,088 BTU/h x no. of pans for compliance gas steamers
454 Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator, preheat energy assumes 15min
455 Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator, preheat energy assumes 20min
456 Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator, preheat energy assumes 15min
457 Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator, preheat energy assumes 20min

Equipment	$BTU_{preheat,ee}$ (BTU)	$BTU/h_{idle,ee}$ (BTU/h)	$(lbs/hr)_{ee}$	Eff_{ee}
Griddle, Electric	1,136 x griddle area[458]	1,092 x griddle area	6.67 x griddle area	0.70
Griddle, Gas	2,500 x griddle area[459]	2,650 x griddle area	7.5 x griddle area	0.38

* For steamers with greater than 6 pans, assume no. pans equals 6 for steamer idle energy rate

Operating Hours

Equipment operating hours per day and days per year shall be taken from the application if known. Default operating hours per day and days per year are provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[460]

Facility Type	hours/day	days/year
Community College	11	283
Fast Food Restaurant	14	363
Full Service Restaurant	12	321
Grocery	12	365
Hospital	11	365
Hotel	20	365
Miscellaneous	9	325
Motel	20	365
Primary School	5	180
Secondary School	8	180
Office	12	250
University	11	283

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

More efficient food service equipment rejects less heat into the condition space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

[458] Food Service Technology Center: Electric Griddle Life-Cycle Cost Calculator
[459] Food Service Technology Center: Gas Griddle Life-Cycle Cost Calculator
[460] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E

Ancillary Electric Savings Impacts

More efficient food service equipment rejects less heat into the condition space than standard equipment, increasing space heating requirements while decreasing cooling load. However, no relevant studies have been performed to date that would allow quantification of these impacts. Until additional information is available, these impacts are excluded from the prescribed formulation of savings.

References

1. ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2, October 2015
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   https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf
2. Food Service Technology Center, Qualified Convection Ovens, February 2018
   Available from: https://fishnick.com/saveenergy/rebates/ovens.pdf
3. ENERGY STAR® Program Requirements Product Specification for Commercial Steam Cookers, Eligibility Criteria Version 1.2, August 2003
   Available from:
   https://www.energystar.gov/sites/default/files/specs/private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf
4. ENERGY STAR® Program Requirements Product Specification for Commercial Fryers Eligibility Criteria Final Draft Version 3.0, October 2016
   Available from:
   https://www.energystar.gov/sites/default/files/Commercial%20Fryers%20Final%20Draft%20V3.0%20Specification.pdf
5. ENERGY STAR® Program Requirements Product Specification for Commercial Griddles, Eligibility Criteria Version 1.2, January 2011
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   https://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Griddles_Program_Requirements.pdf
6. Food Service Technology Center, Qualified Conveyor Ovens, February 2018
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8. Pacific Gas & Electric Company, Work Paper PGECOFST101 Commercial Convection Oven-Electric and Gas, Revision 6, August 2016
9. Pacific Gas & Electric Company, Work Paper PGECOFST117 Commercial Conveyor Oven-Gas, Revision 5, May 2014
10. Pacific Gas & Electric Company, Work Paper PGECOFST109 Commercial Rack Oven-Gas, Revision 5, May 2014
11. Pacific Gas & Electric Company, Work Paper PGECOFST104 Commercial Steam Cooker-Electric and Gas, Revision 6, June 2016

12. Pacific Gas & Electric Company, Work Paper PGECOFST102 Commercial Fryer-Electric and Gas, Revision 6, June 2016
13. Pacific Gas & Electric Company, Work Paper PGECOFST103 Commercial Griddle-Electric and Gas, Revision 7, August 2016
14. Food Service Technology Center: Electric Convection Oven Life-Cycle Cost Calculator Available From: https://caenergywise.com/calculators/electric-convection-ovens/#calc
15. Food Service Technology Center: Gas Convection Oven Life-Cycle Cost Calculator Available From: https://caenergywise.com/calculators/natural-gas-convection-ovens/#calc
16. Food Service Technology Center: Gas Conveyor Oven Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/natural-gas-conveyor-ovens/#calc
17. Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/natural-gas-rack-ovens/#calc
18. Food Service Technology Center: Electric Steamer Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/electric-steamers/#calc
19. Food Service Technology Center: Gas Steamer Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/natural-gas-steamers/#calc
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21. Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/natural-gas-fryers/#calc
22. Food Service Technology Center: Electric Griddle Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/electric-griddles/#calc
23. Food Service Technology Center: Gas Griddle Life-Cycle Cost Calculator Available from: https://caenergywise.com/calculators/natural-gas-griddles/#calc
24. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014
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Record of Revision

Record of Revision Number	Issue Date
3-18-18	3/29/2018

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Dishwasher

Measure Description

This measure covers the installation of ENERGY STAR® qualified electric commercial dishwashers.[461] A dishwasher is a machine designed to clean and sanitize plates, pots, pans, glasses, cups, bowls, utensils, and trays by applying sprays of detergent solution (with or without blasting media granules) and a sanitizing rinse. ENERGY STAR® rated machines consume less water and use less energy while idling between wash cycles. Commercial dishwashers that have earned the label are about 40% more energy efficient than comparable un-qualified models.[462]

This measure applies to stationary rack machines and conveyor machines operating at low or high temperatures. This measure is not applicable to flight machines, which are custom-built, continuous conveyor machines designed for use in large institutions.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times [(\Delta kWh_{wh} \times ElecSF_{wh}) + (\Delta kWh_{booster} \times ElecSF_{booster}) + \Delta kWh_{idle}]$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times [(\Delta therms_{wh} \times GasSF_{wh}) + (\Delta therms_{booster} \times GasSF_{booster})]$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
ΔkWh_{wh}	= Annual electric water heating energy savings
$\Delta kWh_{booster}$	= Annual electric booster water heater energy savings
ΔkWh_{idle}	= Annual electric dishwasher idle energy savings
$ElecSF_{wh}$	= Electric Savings Factor for water heaters
$ElecSF_{booster}$	= Electric Savings Factor for booster water heaters
$\Delta therms_{wh}$	= Annual gas water heating energy savings
$\Delta therms_{booster}$	= Annual gas booster water heater energy savings
$GasSF_{wh}$	= Gas Savings Factor for water heaters
$GasSF_{booster}$	= Gas Savings Factor for booster water heaters

[461] ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers Eligibility Criteria Version 2.0, February 2013

[462] Efficiency of ENERGY STAR® products: https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers

hrs = Annual hours of operation
F_{peak} = Peak operation factor; binary variable to indicate whether equipment operates during electric system peak (summer weekday hour ending at 5PM)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh_{wh}		Look up based on Dishwasher Type in Default Values table below.
$\Delta kWh_{booster}$		Look up based on Dishwasher Type in Default Values table below.
ΔkWh_{idle}		Look up based on Dishwasher Type in Default Values table below.
$ElecSF_{wh}$	Electric WH: 1 Non-Electric WH: 0	
$ElecSF_{booster}$	Electric Booster: 1 Non-Electric Booster: 0	
$\Delta therm_{wh}$		Look up based on Dishwasher Type in Default Values table below.
$\Delta therm_{booster}$		Look up based on Dishwasher Type in Default Values table below.
$GasSF_{wh}$	Non-Gas WH: 0 Gas WH: 1	
$GasSF_{booster}$	Non-Gas Booster: 0 Gas Booster: 1	
hrs		From application. Default values use 6,570 which assumes 18 hours of run time per day, 365 days per year
F_{peak}	Peak Operation: 1 No Peak Operation: 0	From application.
CF	0.9	

Default Values[463]

Dishwasher Type	Elec. DHW (ΔkWh_{wh})	Gas DHW ($\Delta therm_{wh}$)	Elec. Booster ($\Delta kWh_{booster}$)	Gas Booster ($\Delta therm_{booster}$)	Dishwasher (ΔkWh_{idle})
Low Temp, Under Counter	2,540	106	N/A	N/A	0
Low Temp, Stationary Single Tank Door	16,153	675	N/A	N/A	0

463 Deemed savings based on default values listed in Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)

Dishwasher Type	Elec. DHW (ΔkWh_{wh})	Gas DHW ($\Delta therm_{wh}$)	Elec. Booster ($\Delta kWh_{booster}$)	Gas Booster ($\Delta therm_{booster}$)	Dishwasher (ΔkWh_{idle})
Low Temp, Single Tank Conveyor	13,042	545	N/A	N/A	584
Low Temp, Multi-Tank Conveyor	18,811	786	N/A	N/A	0
High Temp, Under Counter	1,082	45	618	26	1,471
High Temp, Stationary Single Tank Door	7,023	294	4,013	168	827
High Temp, Single Tank Conveyor	4,264	178	2,436	102	2,511
High Temp, Multi-Tank Conveyor	16,178	676	9,244	386	1,986
High Temp, Pot, Pan, and Utensil	2,107	88	1,204	50	0

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[464]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a commercial dishwasher as defined in the Measure Description section above with type equivalent to the efficient case. Baseline specifications for idle energy rate, measured in kW, and water consumption, measured in gallons per rack (GPR), used in the formulation of default savings values are provided in the table below.[465]

Machine Type	High Temp		Low Temp	
	Idle Energy Rate (kW)	Water Consumption (GPR)	Idle Energy Rate (kW)	Water Consumption (GPR)
Under Counter	≤ 0.76	≤ 1.09	≤ 0.50	≤ 1.73
Stationary Single Tank Door	≤ 0.87	≤ 1.29	≤ 0.60	≤ 2.10
Single Tank Conveyor	≤ 1.93	≤ 0.87	≤ 1.60	≤ 1.31
Multiple Tank Conveyor	≤ 2.59	≤ 0.97	≤ 2.00	≤ 1.04
Pot, Pan, Utensil	≤ 1.20	≤ 0.70	N/A	N/A

[464] PG&E Work Paper PGECOFST126 Revision 0, Table 10, pg. 18
[465] Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® rated commercial dishwasher as defined in the Measure Description section above. Compliance specifications for idle energy rate, measure in kW, and water consumption, measured in gallons per rack (GPR) used in the formulation of default savings values are provided in the table below.[466]

Machine Type	High Temp		Low Temp	
	Idle Energy Rate (kW)	Water Consumption (GPR)	Idle Energy Rate (kW)	Water Consumption (GPR)
Under Counter	≤ 0.50	≤ 0.86	≤ 0.50	≤ 1.19
Stationary Single Tank Door	≤ 0.70	≤ 0.89	≤ 0.60	≤ 1.18
Single Tank Conveyor	≤ 1.50	≤ 0.70	≤ 1.50	≤ 0.79
Multiple Tank Conveyor	≤ 2.25	≤ 0.54	≤ 2.00	≤ 0.54
Pot, Pan, Utensil	≤ 1.20	≤ 0.58	N/A	N/A

Operating Hours

Operating hours shall come from application. Default savings assumes that dishwashers are available for operation 18 hours per day, 365 days per year.[467]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ENERGY STAR® Program Requirements for Commercial Dishwashers Eligibility Criteria Version 2, February 2013
   Available From:
   https://www.energystar.gov/ia/products/commercial_food_service/comm_dishwashers/Final_Comm_Dish_Spec.pdf
2. ENERGY STAR® Certified Products, Commercial Food Service Equipment, Commercial Dishwashers

[466] Savings Calculator for ENERGY STAR® Commercial Kitchen Equipment (accessed 2/4/2018)
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https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers

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Record of Revision

Record of Revision Number	Issue Date
6-18-18	6/26/2018

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REFRIGERATORS AND FREEZERS

Measure Description

This measure covers the installation of ENERGY STAR® compliant refrigerators and freezers operating with an integral compressor and condenser. Eligible equipment includes commercial standard and hybrid refrigerators, freezers, and refrigerator-freezers. This measure is only applicable to horizontal or vertical self-contained equipment with solid or transparent doors. This measure does not apply to ice cream freezers or refrigeration equipment designed and marketed exclusively toward medical, scientific, or research purposes.

Savings are calculated between the energy consumption of the baseline unit and that of the more efficient equipment meeting ENERGY STAR® minimum performance specifications based on volume.[468]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_{baseline} - kWh_{ee}) \times (1 + HVAC_c)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{kWh_{baseline} - kWh_{ee}}{8{,}760}\right) \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therm = units \times (kWh_{baseline} - kWh_{ee}) \times HVAC_g$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
kWh	= Annual electric energy consumption
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption
CF	= Coincidence factor
8,760	= Hours in one year

[468] ENERGY STAR® Refrigerators & Freezers Key Product Criteria

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		See Baseline Efficiencies section below.
kWh_{ee}		From application.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption (dimensionless), from Appendix D based on facility type, location and HVAC type.
$HVAC_d$		HVAC interaction factor for peak demand at utility summer peak hour (dimensionless), from Appendix D based on facility type, location and HVAC type.
$HVAC_g$		HVAC interaction factor for annual natural gas energy consumption (therms/kWh), from Appendix D based on facility type, location and HVAC type.
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0. [469]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a minimally code compliant commercial standard or hybrid refrigerator, refrigerator-freezer or freezer as defined in the Measure Description section above. Baseline annual electric consumption (kWh/yr) shall align with federally mandated maximum energy use associated with the Product Class and the chilled or frozen compartment volume (V) of the qualifying equipment.[470] Volume specification shall be taken from ENERGY STAR® qualified products listing or specification sheet of the efficient equipment. Baseline maximum daily energy consumption (kWh/day) for solid door and glass door commercial refrigerators and freezers of all volumes are calculated as shown in the table below.[471] For commercial refrigeration equipment with two or more compartments (i.e., hybrid refrigerators, hybrid freezers, hybrid refrigerator-freezers, and non-hybrid refrigerator-freezers), the maximum daily energy consumption for each model shall be the sum of the MDEC values for all of its compartments.[472] Multiply by 365 to derive annual energy consumption.

Type (Closed)	Maximum Daily Energy Consumption (kWh/day)			
	Refrigerator		Freezer	
	Solid Door	Glass Door	Solid Door	Glass Door
Vertical	$\leq 0.05 \times V + 1.36$	$\leq 0.10 \times V + 0.86$	$\leq 0.22 \times V + 1.38$	$\leq 0.29 \times V + 2.95$
Horizontal	$\leq 0.05 \times V + 0.91$	$\leq 0.06 \times V + 0.37$	$\leq 0.06 \times V + 1.12$	$\leq 0.08 \times V + 1.23$

469 *No source specified – update pending availability and review of applicable references.*
470 10 CFR Appendix A to Subpart C of Part 431 – Uniform Test Method for the Measurement of Energy Consumption of Commercial Refrigerators, Freezers, and Refrigerator-Freezers
471 10 CFR 431.66(e)(1)
472 10 CFR 431.66(e)(2)

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified commercial refrigerator, refrigerator-freezer or freezer as defined in the Measure Description section above. ENERGY STAR® rated refrigerators must meet the specifications in the tables below for maximum daily energy consumption (kWh/day).[473] Annual electric energy consumption of the qualifying equipment shall come from application. If unknown, use maximum energy consumption based on qualifying equipment volume from the tables below. Volume specification shall be taken from ENERGY STAR® qualified products listing or specification sheet of the efficient equipment. Multiply by 365 to derive annual energy consumption (kWh/year).

Vertical Closed Energy Consumption

Volume (ft^3)	Maximum Daily Energy Consumption (kWh/day)			
	Refrigerator		Freezer	
	Solid Door	Glass Door	Solid Door	Glass Door
0 < V < 15	≤ 0.022×V+0.97	≤ 0.095×V+0.445	≤ 0.210×V+0.900	≤ 0.232×V+2.36
15 ≤ V < 30	≤ 0.066×V+0.31	≤ 0.050×V+1.120	≤ 0.120×V+2.248	≤ 0.232×V+2.36
30 ≤ V < 50	≤ 0.040×V+1.09	≤ 0.076×V+0.340	≤ 0.285×V-2.703	≤ 0.232×V+2.36
50 ≤ V	≤ 0.024×V+1.89	≤ 0.105×V-1.111	≤ 0.142×V+4.445	≤ 0.232×V+2.36

Horizontal Closed Energy Consumption

Volume (ft^3)	Maximum Daily Energy Consumption (kWh/day)			
	Refrigerator		Freezer	
	Solid Door	Glass Door	Solid Door	Glass Door
All volumes	≤ 0.05×V+0.28	≤ 0.05×V+0.28	≤ 0.057×V+0.55	≤ 0.057×V+0.55

Operating Hours

Refrigeration products are assumed to be plugged into an electrical outlet 8,760 hours per year. Compressor cycling is inherent in the specified annual energy consumption of baseline and qualifying equipment.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

High-efficiency refrigeration products reject less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of facility type, location and HVAC system type are shown in Appendix D.

[473] ENERGY STAR® Program Requirements Product Specification for Commercial Refrigerators and Freezers, Eligibility Criteria Version 4.0

Ancillary Electric Savings Impacts

High-efficiency refrigeration products reject less heat into the conditioned space than standard equipment, increasing space heating requirements while decreasing cooling load. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of facility type, location and HVAC system type are shown in Appendix D.

References

1. ENERGY STAR® Refrigerators & Freezers Key Product Criteria, March 27, 2017
   Available from:
   https://www.energystar.gov/products/commercial_food_service_equipment/commercial_refrigerators_freezers/key_product_criteria
2. 10 CFR Appendix A to Subpart C of Part 431 – Uniform Test Method for the Measurement of Energy Consumption of Commercial Refrigerators, Freezers, and Refrigerator-Freezers
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=fa8761ce7ff31d0c22aaf4e1c4992575&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_166.a
3. 10 CFR 431.66 Energy conservation standards and their effective dates.
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=4892a800dfd3976a79848bb42372bfda&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_166
4. ENERGY STAR® Program Requirements Product Specification for Commercial Refrigerators and Freezers, Eligibility Criteria Version 4.0
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Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
9-18-8	9/28/2018

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ICE MAKER

Measure Description

This measure covers the installation of ENERGY STAR® qualified ice makers. Ice makers are factory-made assemblies consisting of a condensing unit and ice-making section operating as an integrated unit, with means for making and harvesting ice. This measure includes batch-type (cube type) and continuous-type (flake or nugget type) ice makers. Batch-type ice makers have distinct freezing and harvesting periods whereas continuous-type ice makers produce ice through a continuous freezing and harvesting process. Ice makers that have earned the ENERGY STAR® label use approximately 11% less energy and 25% less water than comparable non-qualified models.[474]

This measure covers ice making head, remote condensing, and self-contained air-cooled ice makers. Water-cooled ice makers, ice and water dispensing systems, and air-cooled remote condensing units that are designed only for connection to remote rack compressors are not eligible for energy savings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_{baseline} - kWh_{ee}) \times 365 \times Cycle \times (IHR/100)$$

Peak Coincident Demand Savings

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

Annual Natural Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual natural gas energy savings
units	= Number of measures installed under the program
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
kWh	= Daily electric energy consumption per 100 pounds of ice
Cycle	= Compressor duty cycle
IHR	= Rated Ice Harvest Rate (lbs/day) of the energy efficient ice maker
CF	= Coincidence factor
365	= Days in one year
100	= Factor to convert IHR to units of 100 lbs/day

[474] ENERGY STAR® Ice Machine Key Product Criteria

8,760 = Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{baseline}$		Look up based on efficient Equipment Type and Ice Harvest Rate from Baseline Efficiency section below.
kWh_{ee}		From application. If unknown, look up based on efficient Equipment Type and Ice Harvest Rate from Compliance Efficiencies section below.
IHR		Rated capacity of efficient ice maker from application.
Cycle	0.75	Compressor duty cycle. [475]
CF	0.9	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.9.[476]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a commercial ice maker as defined in the Measure Description section above with Equipment Type and Ice Harvest Rate equivalent to the efficient case. Baseline daily energy use per 100 lbs of ice shall be established based on efficient equipment Ice Harvest Rate in accordance with current federal standards for batch type[477] and continuous type[478] ice makers, as specified in the Code of Federal Regulations and provided in the table below.

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs ($kWh_{baseline}$)
Batch Type, Ice-Making Head	< 300	10 - 0.01233 x IHR
Batch Type, Ice-Making Head	≥ 300 and < 800	7.05 - 0.0025 x IHR
Batch Type, Ice-Making Head	≥ 800 and < 1,500	5.55 - 0.00063 x IHR
Batch Type, Ice-Making Head	≥ 1500 and < 4,000	4.61
Batch Type, Remote Condensing	< 988	7.97 - 0.00342 x IHR
Batch Type, Remote Condensing	≥ 988 and < 4,000	4.59
Batch Type, Self-Contained	< 110	14.79 - 0.0469 x IHR
Batch Type, Self-Contained	≥ 110 and < 200	12.42 - 0.02533 x IHR
Batch Type, Self-Contained	≥ 200 and < 4,000	7.35
Continuous Type, Ice-Making Head	< 310	9.19 - 0.00629 x IHR
Continuous Type, Ice-Making Head	≥ 310 and < 820	8.23 - 0.0032 x IHR
Continuous Type, Ice-Making Head	≥ 820 and < 4,000	5.61
Continuous Type, Remote Condensing	< 800	9.7 - 0.0058 x IHR

[475] PG&E Work Paper PGECOFST108, Revision 5, pg 9
[476] PG&E Work Paper PGECOFST108, Revision 5, pg 12
[477] 10 CFR 431.136 (c)
[478] 10 CFR 431.136 (d)

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs ($kWh_{baseline}$)
Continuous Type, Remote Condensing	≥ 800 and < 4,000	5.06
Continuous Type, Self-Contained	< 200	14.22 - 0.03 x IHR
Continuous Type, Self-Contained	≥ 200 and < 700	9.47 - 0.00624 x IHR
Continuous Type, Self-Contained	≥ 700 and < 4,000	5.1

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an ENERGY STAR® qualified commercial ice maker as defined in the Measure Description above. Efficient condition daily energy use per 100 pounds of ice are established based on efficient equipment Ice Harvest Rate in accordance with ENERGY STAR® maximum qualifying specifications, as shown in the table below.[479]

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs (kWh_{ee})	Potable Water Use (gal/100 lbs ice)
Batch Type, Ice-Making Head	< 300	9.20 - 0.01134 x IHR	≤ 20.0
Batch Type, Ice-Making Head	≥ 300 and < 800	6.49 - 0.0023 x IHR	≤ 20.0
Batch Type, Ice-Making Head	≥ 800 and < 1,500	5.11 - 0.00058 x IHR	≤ 20.0
Batch Type, Ice-Making Head	≥ 1500 and < 4,000	4.24	≤ 20.0
Batch Type, Remote Condensing	< 988	7.17 - 0.00308 x IHR	≤ 20.0
Batch Type, Remote Condensing	≥ 988 and < 4,000	4.13	≤ 20.0
Batch Type, Self-Contained	< 110	12.57 - 0.0399 x IHR	≤ 25.0
Batch Type, Self-Contained	≥ 110 and < 200	10.56 - 0.0215 x IHR	≤ 25.0
Batch Type, Self-Contained	≥ 200 and < 4,000	6.25	≤ 25.0
Continuous Type, Ice-Making Head	< 310	7.90 - 0.005409 x IHR	≤ 15.0
Continuous Type, Ice-Making Head	≥ 310 and < 820	7.08 - 0.002752 x IHR	≤ 15.0
Continuous Type, Ice-Making Head	≥ 820 and < 4,000	4.82	≤ 15.0
Continuous Type, Remote Condensing	< 800	7.76 - 0.00464 x IHR	≤ 15.0
Continuous Type, Remote Condensing	≥ 800 and < 4,000	4.05	≤ 15.0
Continuous Type, Self-Contained	< 200	12.37 - 0.0261 x IHR	≤ 15.0

479 ENEGY STAR® Program Requirements Product Specification for Automatic Commercial Ice Makers, Eligibility Criteria Version 3.0, January 2018

Equipment Type	Ice Harvest Rate (IHR)	Maximum Daily Energy Use per 100 lbs (kWh_{ee})	Potable Water Use (gal/100 lbs ice)
Continuous Type, Self-Contained	≥ 200 and < 700	8.24 - 0.005429 x IHR	≤ 15.0
Continuous Type, Self-Contained	≥ 700 and < 4,000	4.44	≤ 15.0

Operating Hours

Commercial ice makers are assumed to be available for operation 24 hours per day, 365 days per year with a compressor duty cycle of 0.75.[480]

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Efficient ice makers reject less heat than standard equipment, increasing space heating requirements while decreasing cooling load, when located inside a conditioned area. However, this interactivity is considered negligible for the installation of an air-cooled ice maker and is not included in the energy savings calculation.

Ancillary Electric Savings Impacts

Efficient ice makers reject less heat than standard equipment, increasing space heating requirements while decreasing cooling load, when located inside a conditioned area. However, this interactivity is considered negligible for the installation of an air-cooled ice maker and is not included in the energy savings calculation.

References

1. ENERGY STAR® Program Requirements Product Specification for Automatic Commercial Ice Makers Eligibility Criteria Version 3.0, January 2018
   Available from:
   https://www.energystar.gov/sites/default/files/asset/document/Final%20V3.0%20ACIM%20Specification%205-17-17_1_1.pdf
2. ENERGY STAR® Certified Products, Commercial Ice Makers
   Available from:
   https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers
3. Pacific Gas & Electric Work Paper PGECOFST108 Commercial Ice Machines, Revision 5, August 2016
   Available from: www.deeresources.net/workpapers

480 PG&E Work Paper PGECOFST108, Revision 5, pg 9

4. 10 CFR 431.136 Energy conservation standards and their effective dates
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=62fc415d2221a3b1166362f5a2949044&mc=true&node=sp10.3.431.h&rgn=div6#se10.3.431_1136

Record of Revision

Record of Revision Number	Issue Date
6-18-19	6/26/2018

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APPLIANCE – CONTROL

TIER 1 ADVANCED POWER STRIP

Measure Description

This measure covers the installation of Tier 1 Advanced Power Strips (APS) in office workstations. The Tier 1 APS makes use of a control outlet to disconnect the controlled plugs when the load on the control outlet (usually a computer) is reduced below a threshold. In this case, the reduction below threshold of the control plug happens when the computer shuts down or enters standby mode. Therefore, the overall load of a centralized group of equipment (e.g. monitors and other peripherals for the computer) can be reduced.

Method for Calculating Annual Energy and Peak Coincident Demand Savings[481]

Annual Electric Energy Savings

$$\Delta kWh = units \times \begin{bmatrix} \Delta kW_{wkday} \times \left(hrs_{wkday} - hrs_{wkday-open}\right) \\ + \\ \Delta kW_{wkend} \times \left(hrs_{wkend} - hrs_{wkend-open}\right) \end{bmatrix} \times \frac{8{,}760}{168}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
ΔkW_{wkday}	= Average power reduction during weekday off hours
ΔkW_{wkend}	= Average power reduction during weekend off hours
hrs_{wkday}	= Total hours during the work week (Monday 7:30 AM to Friday 5:30 PM)
hrs_{wkend}	= Total hours during the weekend (Friday 5:30 PM to Monday 7:30 AM)
$hrs_{wkday,open}$	= Hours the office is open during the work week
$hrs_{wkend,open}$	= Hours the office is open during the weekend
8,760	= Hours in one year
168	= Hours in one week

[481] Savings algorithm reconstructed from weekday and weekend savings information in Sheppy *et. al*, and verified against savings in Acker *et. al* and savings in: BPA, "Smart Power Strip Energy Savings Evaluation: Ross Complex," (2011). Office stations are assumed to have zero or minimal standby losses during normal operating hours.

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkW_{wkday}	0.0315	Deemed value from IDL and NREL/NAVFAC study, determined by reduction in off-hours demand. See Deemed Savings Background section below for additional detail.
ΔkW_{wkend}	0.0067	Deemed value from IDL and NREL/NAVFAC study, determined by reduction in off-hours demand. See Deemed Savings Background section below for additional detail.
hrs_{wkday}	106	
$hrs_{wkday,open}$		From application. If unknown, use 50 hours.[482]
hrs_{wkend}	62	
$hrs_{wkend,open}$		From application. If unknown, use 0 hours.[483]

Deemed Savings Background

Since the introduction of the Tier 1 APS for commercial applications, three studies of its performance in commercial office settings have been conducted. Their ex-post estimates for savings are in relative agreement, between 134 and 149 kWh. The three studies are:

1. A University of Idaho Integrated Design Lab (IDL) project studying 49 load-sensing power strips in a large, private office building. Baseline data was gathered for one year and post-period data was gathered for 3 months. The study broke out findings into weekday, weekend, and holiday categories.[484]
2. A National Renewable Energy Laboratory (NREL) and Naval Facilities Engineering Command (NAVFAC) joint APS evaluation, with 100 load-sensing power strips. Whole building load shapes were monitored pre and post. This study had five weeks of baseline data and six weeks of treatment data.[485]
3. A Bonneville Power Administration APS evaluation at the Ross Complex, in which 48 strips were installed for a pre- and post-treatment period of three weeks each. Data for this study was measured at the individual power strip level.[486]

The calculation for energy savings uses the detailed breakdowns of energy savings from the IDL study and the assumption that savings only occur outside of normal business hours. The value of 31.5 watts reduced during off-hours on weekdays was calculated with data from the IDL study and aligns with the graphically shown load reduction in the NREL/NAVFAC study. The same method was performed for the weekends to obtain the wattage reduced. The number from the IDL study of 6.7 watts reduced on weekends is more conservative than the NREL/NAVFAC results and is used for this calculation.

[482] Assumes an office operating schedule of M - F, 7:30AM – 5:30PM
[483] Assumes an office operating schedule of M - F, 7:30AM – 5:30PM
[484] Acker *et al*
[485] Sheppy *et al*
[486] BPA, “Smart Power Strip Energy Savings Evaluation,” Ross Complex, Vancouver, WA (2011)

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A. The majority of kWh savings are assumed to occur during off-hours, so no peak coincident demand savings are deemed.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an office workstation with no plug load control system.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an office workstation with a tier 1 plug load control advanced power strip.

Operating Hours

The annual operating hours of the measure, assuming that the APS is operating when it is reducing load, can be calculated by:

$$hours = \begin{bmatrix} (hrs_{wkday} - hrs_{wkday-open}) \\ + \\ (hrs_{wkend} - hrs_{wkend-open}) \end{bmatrix} \times \frac{8{,}760}{168}$$

Which is equal to 6,153 hours, assuming that the office is open for 50 hours on weekdays and 0 hours on weekends. Alternatively, the operating hours of the workstation standby loads are reduced by this amount, to 2,607 hours from 8,760 hours.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Acker, Brad et. al, “Office Space Plug Load Profiles and Energy Saving Interventions,” IDL, 2012 ACEEE Summer Study on Energy Efficiency in Buildings (2012) Available from: https://fortress.wa.gov/ga/apps/SBCC/File.ashx?cid=5572
2. Sheppy, M. et al, “Reducing Plug Loads in Office Spaces” Hawaii and Guam Energy Improvement Technology Demonstration Project, NREL/NAVFAC (January 2014) Available from: https://www.nrel.gov/docs/fy14osti/60382.pdf

3. Bonneville Power Administration, "Smart Power Strip Energy Savings Evaluation," Ross Complex, Vancouver, WA (2011)
Available from: http://studylib.net/doc/8460015/smart-strip-energy-savings-evaluation-%E2%80%93-ross-complex--van...

Record of Revision

Record of Revision Number	Issue Date
12-17-16	12/31/2017

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Vending Machine and Novelty Cooler Control

Measure Description

This measure covers the installation of time clocks and occupancy sensors on vending machines and novelty coolers to ensure units maintain desired product temperatures when required. The time clock control mechanism is a programmed-schedule time clock that is assumed to be set to turn the equipment off coincident with the facility closing time and turn equipment on one hour before opening time to allow the products to return to the desired sale temperature.

The occupancy sensor control mechanism uses an infrared sensor to turn off the vending machine when the surrounding area is unoccupied. The device also monitors the ambient temperature and powers up the machine as required to keep products cool. Additionally, the sensor monitors the electrical current used by the machine to ensure it is not turned off during a compressor cycle to prevent a high head pressure start from occurring.

This measure is only applicable to vending machines without a low power mode. A low power mode is a state in which a vending machine's lighting, refrigeration, and/or other energy using systems are automatically adjusted (without user intervention) such that they consume less energy than they consume in an active vending environment.[487] This measure is only applicable to vending machines and novelty coolers containing non-perishable products.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (kW/unit) \times hrs_{off} \times Cycle$$

Peak Coincident Demand savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
(kW/unit)	= Vending machine power (kW), based on nameplate Volts, Amps, Phase and Power Factor
hrs_{off}	= Unit off hours per year
Cycle	= Compressor duty cycle

[487] 10 CFR 431 Subpart Q, Appendix B 1.2 Definitions

Summary of Variables and Data Sources

Variable	Value	Notes
(kW/unit)	$= Volts \times Amps \times \sqrt{Phase} \times PF$	Based on nameplate Volts, Amps, Phase and Power Factor. If power factor is unknown, use a default value of 0.55.[488]
hrs_{off}	Time clock: From application Occupancy Sensor: 2,891	Based on control type. For time clocks, off hours are equivalent to annual facility closed hours minus facility operating days. If unknown, look up in Operating Hours section below based on facility type.
Cycle	0.45	Compressor average duty cycle. [489]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Incentives are Calculated

The baseline condition is a vending machine or novelty cooler containing non-perishable products without time clock or occupancy IR sensing/load sensing control.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a vending machine or novelty cooler containing non-perishable products with time clock or occupancy IR sensing/load sensing control installed.

Operating Hours

Novelty coolers and refrigerated vending machines are assumed to be connected 24 hours per day, 365 days per year. In the baseline case, these units operate during all hours and cycle according to the duty cycle cited above.

With time clock control, units are automatically shut off when the facility closes and turned back on one hour prior to the facility opening to allow the system to return the contents to their desired temperature. Energy savings are calculated based on the system off hours due to installed time clock control. If unknown, use the default off hours based on building type from the table below. This table was developed by subtracting the default lighting hours in the C&I Interior Lamps and Fixtures measure in this TRM from 8,760, and subtracting 365 from the result (assumes 365 days of facility operation). Facilities expected to operate 24/7 are excluded.

[488] Analysis of Cooler Control Energy Conservation Measures: Final Report, Select Energy Services, Inc., March 2004
[489] Ibid

Facility Type	hrs_{off} (hrs/yr)	Facility Type	hrs_{off} (hrs/yr)
Auto Related[a]	5,585	Manufacturing Facility	5,538
Bakery	5,541	Medical Offices	4,647
Banks	4,647	Motion Picture Theatre	6,441
Church	6,440	Museum	4,647
College– Cafeteria[b]	5,682	Nursing Homes	2,555
College – Classes	5,809	Office (General Office Types)[b]	5,382
College - Dormitory	5,329	Parking Garages	4,027
Commercial Condos[c]	5,295	Parking Lots	4,295
Convenience Stores	2,019	Penitentiary	2,918
Convention Center	6,441	Performing Arts Theatre	5,809
Court House	4,647	Post Office	4,647
Dining: Bar Lounge/Leisure	4,213	Pump Stations	6,446
Dining: Cafeteria / Fast Food	1,939	Refrigerated Warehouse	5,793
Dining: Family	4,213	Religious Building	6,440
Entertainment	6,443	Restaurants	4,213
Exercise Center	2,559	Retail	4,932
Fast Food Restaurants	2,019	School / University	6,208
Fire Station (Unmanned)	6,442	Schools (Jr./Sr. High)	6,208
Food Stores	4,340	Schools (Preschool/Elementary)	6,208
Gymnasium	5,809	Schools (Technical/Vocational)	6,208
Industrial - 1 Shift	5,538	Small Services	4,645
Industrial - 2 Shift	3,665	Sports Arena	6,441
Industrial - 3 Shift	1,764	Town Hall	4,647
Laundromats	4,339	Transportation	1,939
Library	4,647	Warehouse (Not Refrigerated)	5,793
Light Manufacturers[b]	5,782	Waste Water Treatment Plant	1,764
Lodging (Hotels/Motels)	5,331	Workshop	4,645
Mall Concourse	3,562		

[a] New car showrooms and Big Box retail stores with evening and/or weekend hours should use the Facility Type "Retail" for vending machine and novelty cooler off hours
[b] Lighting operating hours data from the 2008 California DEER Update study
[c] Lighting operating hours data for offices used

Annual occupancy sensor control hours are assumed to be 2,891 based on 33% energy savings of vending machine or novelty with installed device.[490]

Effective Useful Life (EUL)

See Appendix P.

[490] Analysis of NREL Cold-Drink Vending Machines for Energy Savings, June 2003.

Ancillary Fossil Fuel Savings Impacts

Reduced refrigeration system run hours during facility operation will result in a slight increase in space heating requirements and a slight decrease in space cooling requirements. These effects are not considered in the prescribed savings methodology.

Ancillary Electric Savings Impacts

Reduced refrigeration system run hours during facility operation will result in a slight increase in space heating requirements and a slight decrease in space cooling requirements. These effects are not considered in the prescribed savings methodology.

References

1. 10 CFR 431 Subpart Q, Appendix B, 1.2 Definitions
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=bffd54323b0e3f933976ce4b4ad86e55&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1296.b
2. Analysis of Cooler Control Energy Conservation Measures: Final Report, Select Energy Services, Inc., March 2004
   Available from: https://forum.cee1.org/system/files/library/1220/392.pdf
3. Analysis of NREL Cold-Drink Vending Machines for Energy Savings, NREL, June 2003
   Available from:
   https://www.researchgate.net/profile/Michael_Deru/publication/242168498_Analysis_of_NREL_Cold-Drink_Vending_Machines_for_Energy_Savings/links/54bd240d0cf218da939190ab/Analysis-of-NREL-Cold-Drink-Vending-Machines-for-Energy-Savings.pdf?origin=publication_detail

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-7	6/26/2018

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APPLIANCE RECYCLING

AIR CONDITIONER – ROOM (WINDOW)

Measure Description

Room (Window) Air Conditioners, a consumer (appliance) product, other than a "packaged terminal air conditioner," which is powered by a single-phase electric current and is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating[491]. Minimum energy conservation standards for these appliances have been established by the Code for Federal Regulations 10 CFR 430.32(b). As this standard continues to be revised, and by association ENERGY STAR® standards continue to increase, operational savings attributable to new RAC may justify early retirement before the full useful life has been exhausted. In order to realize the anticipated savings, a currently functioning appliance of equivalent cooling capacity and type having been manufactured before June 2014 must be properly disposed of when a new appliance is supplied to the customer.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings, Method using EER

$$\Delta kWh = units \times \frac{Capacity}{1{,}000} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times EFLH_{cooling}$$

Annual Electric Energy Savings, Alternate Method using CEER[492]

$$\Delta kWh = units \times \frac{Capacity}{1{,}000} \times \left(\frac{1}{CEER_{baseline}} - \frac{1}{CEER_{ee}}\right) \times EFLH_{cooling}$$

Peak Coincident Demand Savings, Method using EER

$$\Delta kW = units \times \frac{Capacity}{1{,}000} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times CF$$

Peak Coincident Demand Savings, Alternate Method using CEER

$$\Delta kW = units \times \frac{Capacity}{1{,}000} \times \left(\frac{1}{CEER_{baseline}} - \frac{1}{CEER_{ee}}\right) \times CF$$

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491 ENERGY STAR® Program Requirements, Product Specification for Room Air Conditioners, Eligibility Criteria Version 4.0, February 2015

492 When available the Combined Energy Efficiency Ratio should be used for the purpose of calculating annual electric energy savings.

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures recycled under the program
Capacity = Cooling output rating, in BTU/h
$EFLH_{cooling}$ = Cooling Equivalent Full-Load Hours
CF = Coincidence Factor
CEER = Combined Energy Efficiency Ratio
EER = Energy Efficiency Ratio
$_{ee}$ = Energy efficient condition or measure
$_{baseline}$ = Baseline condition or measure
1,000 = Conversion factor (1,000 Watts / Kilowatt)

Packaged Terminal Air Conditioner (PTAC) is defined as a wall sleeve and a separate unencased combination of heating and cooling assemblies specified by the builder and intended for mounting through the wall.

RAC with louvered sides have exterior side vents to facilitate airflow over the outdoor coil.

RAC with reverse cycle are appliances that may reverse the refrigeration cycle so as to serve as heating equipment, also known as a heat pump.

Summary of Variables and Data Sources

Variable	Value	Notes
Capacity		From application.
$EFLH_{cooling}$		Cooling equivalent full-load hours by building type, see Appendix G.
$CEER_{baseline}$		From application, or lookup from table below based on unit capacity when unknown.
$CEER_{ee}$		From application.
$EER_{baseline}$		From application, or lookup from table below based on unit capacity when unknown.
EER_{ee}		From application.
CF	NYC: 0.703 Elsewhere: 0.305	

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.703 for NYC and 0.305 elsewhere.[493]

Baseline Efficiencies from which Savings are Calculated[494]

Baseline efficiency assumptions for normal replacement of units manufactured between the years 2000 – 2014 are shown below. Baseline efficiency of air conditioners manufactured after June 2014 will be the compliance efficiency.

Room Air Conditioners

Capacity (BTU/h)	with Louvered Sides ($EER_{baseline}$)	Capacity (BTU/h)	without Louvered Sides ($EER_{baseline}$)
< 6,000	≥ 9.7	< 6,000	≥ 9.0
6,000 – 7,999	≥ 9.7	6,000 – 7,999	≥ 9.0
8,000 – 13,999	≥ 9.8	8,000 – 10,999	≥ 8.5
14,000 – 19,999	≥ 9.7	11,000 – 13,999	≥ 8.5
20,000– 27,999	≥ 8.5	14,000– 19,999	≥ 8.5
≥ 28,000	≥ 8.5	≥ 20,000	≥ 8.5

Room Air Conditioners – Casement

Capacity (BTU/h)	Casement Only ($EER_{baseline}$)	Casement - Slider ($EER_{baseline}$)
All	≥ 8.7	≥ 9.5

Room (Air Conditioners with Reverse Cycle) Heat Pumps

Capacity (BTU/h)	with Louvered Sides ($EER_{baseline}$)	Capacity (BTU/h)	without Louvered Sides ($EER_{baseline}$)
≤ 19,999	≥ 9.0	≤ 13,999	≥ 8.5
≥ 20,000	≥ 8.5	≥ 14,000	≥ 8.0

Compliance Efficiency from which Incentives are Calculated[495]

Units will be treated as early retirement and total lifetime energy savings will be calculated based on remaining years of useful life (RUL) of the existing baseline unit. Units greater than 9 years old will be considered normal replacements and will be given incremental savings. Incremental savings are defined as the difference between the annual kWh consumption of minimally compliant with Federal appliance standards and the annual kWh consumption of the new unit.

Room Air Conditioners

Capacity (BTU/h)	with Louvered Sides (EER_{ee})	Capacity (BTU/h)	without Louvered Sides (EER_{ee})
< 6,000	≥ 11.0	< 6,000	≥ 10.0

[493] C&I Unitary HVAC Load Shape Project Final Report, KEMA, 2011, Table 0-6: NY - Inland and NY - Urban/Coastal
[494] 10 CFR 430.32(b) Baseline EER based on manufactured dates between 10/1/2000 and 5/31/2014.
[495] 10 CFR 430.32(b) Compliance EER based on manufactured dates after 6/1/2014.

Capacity (BTU/h)	with Louvered Sides (EER_{ee})	Capacity (BTU/h)	without Louvered Sides (EER_{ee})
6,000 – 7,999	≥ 11.0	6,000 – 7,999	≥ 10.0
8,000 – 13,999	≥ 10.9	8,000 – 10,999	≥ 9.6
14,000 – 19,999	≥ 10.7	11,000 – 13,999	≥ 9.5
20,000– 27,999	≥ 9.4	14,000– 19,999	≥ 9.3
≥ 28,000	≥ 9.0	≥ 20,000	≥ 9.4

Room Air Conditioners – Casement

Capacity (BTU/h)	Casement Only (EER_{ee})	Casement - Slider (EER_{ee})
All	≥ 9.5	≥ 10.4

Room (Air Conditioners with Reverse Cycle) Heat Pumps

Capacity (BTU/h)	with Louvered Sides (EER_{ee})	Capacity (BTU/h)	without Louvered Sides (EER_{ee})
≤ 19,999	≥ 9.8	≤ 13,999	≥ 9.3
≥ 20,000	≥ 9.3	≥14,000	≥ 8.7

Operating Hours

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

Effective Useful Life (EUL)

For equipment 9 years old or older:
See Appendix P.

Remaining Useful Life (RUL)

For equipment less than 9 years old:
Years: 9 – (Current Year – Year Manufactured)

1. *Subtract the year of manufacture from the current year*
2. *Subtract the result of step (1) from 9*

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. CFR 10-430.32 Energy and water conservation standards and their compliance dates. Available from: http://www.ecfr.gov/cgi-bin/text-idx?SID=4044895882a37a32c525095b1ad5ad69&mc=true&node=se10.3.430_132&rgn=div8

2. *C&I Unitary HVAC Load Shape Project Final Report*, KEMA, August 2, 2011, Table 0-6; (accessed March 21, 2017)
   Available from:
   http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2.pdf
3. ENERGY STAR® Program Requirements, Product Specification for Room Air Conditioners, Eligibility Criteria, Version 4.0, February 2015
   Available from:
   https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%204.0%20Room%20Air%20Conditioners%20Specification.pdf
4. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: HV-RAC-ES
   Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

Record of Revision Number	Issue Date
1-16-15	12/31/2015
4-16-2	3/31/2015
6-17-8	6/30/2017

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BUILDING SHELL

COOL ROOF

Measure Description

This measure covers the installation of roofing material with reduced solar absorptance. Cool roofs reduce heat gains and alleviate cooling HVAC loads. State regulations require a minimum three-year aged solar reflectance of 0.55 and thermal emittance of 0.75 and a solar reflectance index of 64.[496] In currently available system models, the cool roof (qualifying) is assumed to have a solar absorptance of 0.3 compared to a standard roof (baseline) with solar absorptance of 0.8. Due to negative impacts on space heating, this measure is applicable to buildings with air conditioning and gas heat only.

This measure is only applicable to existing buildings constructed before 2012 that have not undergone roof improvements since 2012.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
$1{,}000ft^2$	= Thousand square feet of installed cool roof
$\Delta kWh/1{,}000ft^2$	= Annual electric energy savings per thousand square feet of cool roof
$\Delta kW/1{,}000ft^2$	= Peak coincident demand electric savings per thousand square feet of cool roof
$\Delta therms/1{,}000ft^2$	= Annual gas energy savings per thousand square feet of cool roof
CF	= Coincidence factor

[496] ECCCNYS 2016 & NYCECC 2016 Table C402.3: Minimum Roof Reflectance and Emittance Options

Summary of Variables and Data Sources

Variable	Value	Notes
1,000ft^2		From application.
ΔkWh/1,000ft^2		Look up based on building type and city in Appendix I.
ΔkW/1,000ft^2		Look up based on building type and city in Appendix I.
Δtherms/1,000ft^2		Look up based on building type and city in Appendix I.
CF	0.8	

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a series of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy and demand savings by building type and city are shown in Appendix I.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[497]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a roof without reduced solar absorptance, which is assumed to have a solar absorptance of 0.8.[498]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a roof installed with reduced solar absorptance. Qualifying roofs shall have a minimum of three-year aged solar reflectance of 0.55 and thermal emittance of 0.75 and a three-year aged solar reflectance index of 64.[499]

Look up compliance cool roof efficiency from Appendix I based on building type and location. Models for cool roof efficiency congruent with state code are currently under development; available roof efficiencies assume a solar absorptance of 0.3.[500]

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

[497] *No source specified – update pending availability and review of applicable references.*
[498] California Title 24 Standards
[499] ECCCNYS 2016 & NYCECC 2016 Table C402.3: Minimum Roof Reflectance and Emittance Options
[500] California Title 24 Standards

Ancillary Fossil Fuel Savings Impacts

Reducing roofing material solar absorptance increases space heating requirements. The natural gas impacts are detailed above.

Ancillary Electric Savings Impacts

N/A

References

1. ECCCNYS 2016, per IECC 2015; Table C402.3 Minimum Roof Reflectance and Emittance Options
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016; Table C402.3 Minimum Roof Reflectance and Emittance Options
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
3. Roof absorptivity assumptions taken from California Title 24 Standards for conventional and cool roofs

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1	10/15/2010
9-18-9	9/28/2018

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HOT WATER AND STEAM PIPE INSULATION

Measure Description

This measure covers the installation of fiberglass or rigid foam/cellular glass pipe insulation in space heating hot water/steam and domestic hot water (DHW) distribution systems on piping with a nominal diameter between 0.75″ and 8.00″. Estimation of energy savings depend on the type and size of the pipe, type and thickness of the insulation, supply temperature of the heating medium and ambient temperature.

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = \frac{(UA/L)_{baseline} - (UA/L)_{ee}}{E_{t,gas} \times 100{,}000} \times L \times \Delta T_{amb} \times hrs \times GasSF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
baseline	= Baseline condition or measure
ee	= Energy efficient measure
(UA/L)	= Overall heat transfer coefficient per unit length (BTU/h-°F-ft)
E_t	= Thermal efficiency of hot water or steam system
l	= Length of installed insulation (ft) in unconditioned spaces
ΔT_{amb}	= Temperature difference between hot water or steam in pipe and surrounding ambient air temperature (°F)
hrs	= Annual operating hours

ElecSF	= Electric Savings Factor for water heaters: Adjustment to electric water heating energy savings based on water heating fuel
GasSF	= Gas Savings Factor for water heaters: Adjustment to gas water heating energy savings based on water heating fuel
CF	= Coincidence factor
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(UA/L)_{baseline}$		Lookup from Baseline Efficiencies section below, based on pipe diameter.
$(UA/L)_{ee}$		Lookup from Compliance Efficiency section below, based on pipe diameter and insulation type and thickness.
$E_{t,elec}$	DHW: 0.98	From application. If unknown, use default thermal efficiency of typical electric storage type water heater provided.[501]
$E_{t,gas}$	DHW: 0.80 HW and Steam Boilers: See Boiler Efficiencies section below	From application. If unknown, use default efficiency of typical gas storage type water heater and boiler efficiencies provided. [502]
L		From application.
ΔT_{amb}	$T_{pipe} – T_{amb}$	
T_{pipe}	DHW: 140 HW Boiler: 160 Steam Boiler: 212	Average temperature of hot water in distribution system piping (°F). [503]
T_{amb}	DHW: 70 Space Heat: 50	Surrounding average ambient air temperature (°F). [504,505]
ElecSF	Electric WH: 1.0 Gas WH: 0 Unknown WH: 0.45 Space Heat: 0	Based on EIA Commercial Buildings Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[506]

[501] Per 10 CFR 431 Subpart G, Appendix B 5.7.1
[502] Per 10 CFR 431.110 (a)
[503] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
[504] Average annual ambient temperature in unconditioned spaces
[505] Average ambient temperature based on typical heating season conditions of unconditioned basements
[506] EIA Commercial Building Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States, Table B4, Water-heating energy sources (“Unknown” calculated as the number of buildings with electric water heating divided by the total number of buildings with electric or gas water heating)

Variable	Value	Notes
GasSF	Electric WH: 0 Gas WH: 1.0 Unknown: 0.55 Space Heat: 1.0	Based on EIA Commercial Buildings Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States.[507]
hrs	DHW: 8,760 Space Heat: $EFLH_{heating}$ (Appendix G)	See Operating Hours section below.
CF	Electric DHW: 1.0 Hot Water: N/A	

Boiler Efficiency

Efficiency for commercial boilers is defined by the Code of Federal Regulations (CFR) and subsequently adopted by the Energy Conservation Construction Code of New York State[508] and the New York City Energy Conservation Code[509] as shown below.

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5, and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.80 AFUE	0.80 AFUE
	≥ 300kBTU/h and ≤ 2,500 kBTU/h	0.80 E_t	0.80 E_t
	> 2,500 kBTU/h	0.82 E_c	0.82 E_c
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300kBTU/h and ≤ 2,500 kBTU/h	0.79 E_t	0.79 E_t
	> 2,500 kBTU/h	0.79 E_t	0.79 E_t
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300kBTU/h and ≤ 2,500 kBTU/h	0.77 E_t	0.77 E_t
	> 2,500 kBTU/h	0.77 E_t	0.77 E_t

Coincidence Factor (CF)

The prescribed value for the coincidence factor for domestic water heating is 1.0.[510]
The prescribed value for the coincidence factor for hot water heating is N/A.

[507] EIA Commercial Building Energy Consumption Survey (CBECS) 2012 for Middle Atlantic States, Table B4, Water-heating energy sources ("Unknown" calculated as the number of buildings with gas water heating divided by the total number of buildings with electric or gas water heating)
[508] ECCCNYS 2016, Table C403.2.3(5)
[509] NYCECC 2016, Table C403.2.3(5)
[510] *No source specified – update pending availability and review of applicable references.*

Baseline Efficiencies from which Savings are Calculated

The baseline condition is bare copper or steel domestic hot water or space heating piping. Prescribed $(UA/L)_{baseline}$ values are provided in the table below based on the diameter of pipe, pipe material, and application. CPVC, PEX and HDPE piping were not considered but are being evaluated for inclusion in a future revision. Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Calculations were developed with NAIMA's 3E Plus software program.[511]

Pipe Diam. (in)	$(UA/L)_{baseline}$				
	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45
4.00	1.98	2.14	2.40	2.43	2.73
5.00	2.41	2.61	2.92	2.97	3.34
6.00	2.84	3.07	3.45	3.50	3.94
8.00	3.64	3.94	4.42	4.50	5.06

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a length of service hot water or space heating hot water/steam distribution piping insulated in accordance with ECCCNYS[512] and NYCECC[513]. Minimum required insulation thicknesses per material conductivity are outlined in the table below based on fluid operating temperature and pipe diameter ranges.

Fluid Operating Temperature Range and Usage (°F)	Conductivity BTU-in/h-ft^2-F	Mean Rating Temperature	Nominal Pipe or Tube Size (in)				
			< 1	≥ 1 and < 1.5	≥ 1.5 and < 4	≥ 4 and < 8	8
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.5

[511] Insulation Institute, 3E Plus® Version 4.1
[512] ECCCNYS 2016, Table C403.2.10 Minimum Pipe Insulation Thickness
[513] NYCECC 2016, Table C403.2.10 Minimum Pipe Insulation Thickness

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

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

where:

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

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

The $(UA/L)_{ee}$ values associated with fiberglass and rigid foam/cellular glass insulation of various thicknesses provided in the table below shall be used to establish the compliance condition heat transfer coefficient. Pipe diameter and insulation type and thickness shall be taken from the application. The values below were calculated assuming a k-value of 0.25 BTU-in/hr-°F-ft^2 for fiberglass and 0.35 BTU-in/ hr-°F-ft^2 for rigid foam/cellular glass insulation at 100°F. Pipe wall resistance and exterior film resistance were not considered in the derivation of the values below. Calculations were developed with NAIMA's 3E Plus software program.[514]

Pipe Diam. (in)	$(UA/L)_{ee}$											
	Fiberglass						**Rigid Foam/Cellular Glass**					
	0.5 in	**1 in**	**1.5 in**	**2 in**	**2.5 in**	**3 in**	**0.5 in**	**1 in**	**1.5 in**	**2 in**	**2.5 in**	**3 in**
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19
5.00	0.52	0.34	0.26	0.22	0.19	0.17	0.58	0.41	0.33	0.28	0.25	0.22
6.00	0.61	0.39	0.30	0.25	0.21	0.19	0.67	0.47	0.37	0.32	0.28	0.25
8.00	0.77	0.49	0.37	0.30	0.26	0.23	0.84	0.59	0.46	0.39	0.34	0.30

Service hot water pipe insulation for non-recirculating systems is limited to insulation of hot water

[514] Insulation Institute, 3E Plus® Version 4.1

distribution pipe in unconditioned spaces. Space heating pipe insulation is limited to insulation installed in unheated spaces only.

Operating Hours

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

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. 10 CFR 431 Subpart G – Commercial Water Heaters, Hot Water Supply Boilers and Unfired Hot Water Storage Tanks, Appendix B - Uniform Test Method for Measuring the Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=e0518d0e0befdd3d0f69d20f62691096&mc=true&node=pt10.3.431&rgn=div5#ap10.3.431_1110.b
2. 10 CFR 431.110 Energy Conservation Standards and Their Effective Dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=e0518d0e0befdd3d0f69d20f62691096&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1110
3. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems
   Available from: https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
4. EIA Commercial Building Energy Consumption Survey (CBECS) 2012 Survey Data for Middle Atlantic States, May 2016
   Available from: https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b4.php
5. ECCCNYS 2016, per IECC 2015; Table C404.2 Minimum Performance of Water-heating Equipment & Table C403.2.10 Minimum Pipe Insulation Thickness
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
   https://codes.iccsafe.org/public/document/IECC2015NY/chapter-4-re-residential-energy-efficiency

6. NYCECC 2016; Table C403.2.10 Minimum Pipe Insulation Thickness & NYCECC 2016; Table C403.2.10 Minimum Pipe Insulation Thickness
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
7. 3E Plus, NAIMA, Insulation Institute, Version 4.1
   Available from: https://insulationinstitute.org/tools-resources/free-3e-plus/

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12-18-9	12/28/2018

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WINDOW – FILM

Measure Description

This measure covers the installation of window films with reduced solar heat gain coefficient applied to single pane clear glass. Windows with lower solar heat gain coefficient lead to less required cooling loads within a conditioned space.

Due to negative impacts on space heating, this measure is applicable to buildings with electric AC and gas heat only. This measure is applicable to uncovered, single pane clear glass windows in existing buildings only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{ft^2}{100} \times \frac{\Delta kWh}{100ft^2}$$

Peak Coincident Demand Savings

$$\Delta kW = \frac{ft^2}{100} \times \frac{\Delta kW}{100ft^2} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = \frac{ft^2}{100} \times \frac{\Delta therms}{100ft^2}$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
ft^2 = Total aperture area of window glazing treated, in square feet
$\Delta kWh/100ft^2$ = Electricity consumption savings per 100 square feet of glazing area
$\Delta kW/100ft^2$ = Electricity consumption savings per 100 square feet of glazing area
$\Delta therm/100ft^2$ = Gas consumption savings per 100 square feet of glazing area
100 = Conversion to 100 square feet
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
ft^2		From application.
$\Delta kWh/100ft^2$		Lookup based on building type and location from the Window Film section of Appendix F.
$\Delta kW/100ft^2$		Lookup based on building type and location from the Window

Variable	Value	Notes
		Film section of Appendix F.
Δtherm/100ft^2		Lookup based on building type and location from the Window Film section of Appendix F.
CF	0.8	

Unit energy and demand savings were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy and demand savings by building types across different cities in NY are shown in the Window Film section of Appendix F.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[515]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing, untreated, single pane clear glass window with an assumed solar heat gain coefficient of 0.87 and U-value of 1.2 BTU/h- ft^2-°F.[516]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an existing window with added film with a solar heat gain coefficient of 0.40 or less.

Operating Hours

The HVAC system operating hours vary by building type. Operating hour assumptions for the prototypical building models are described in Appendix A.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ASHRAE 2013 Handbook of Fundamentals by American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). Atlanta, GA, 2013.

[515] *No source specified – update pending availability and review of applicable references.*
[516] ASHRAE 2013 Handbook of Fundamentals

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1	10/15/2010
9-18-10	9/28/2018

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WINDOW – GLAZING

Measure Description

ENERGY STAR® windows with reduced thermal conductance and solar heat gain coefficient.[517]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{ft^2}{100} \times \frac{\Delta kWh}{100\ ft^2} \times \frac{SEER_{baseline}}{SEER_{part}} \times \left[\frac{\overline{Eff}_{dist,baseline}}{\overline{Eff}_{dist,part}}\right]_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{ft^2}{100} \times \frac{\Delta kW}{100\ ft^2} \times \frac{EER_{baseline}}{EER_{part}} \times \left[\frac{Eff_{dist,pk,baseline}}{Eff_{dist,pk,part}}\right]_{cooling} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{ft^2}{100} \times \frac{\Delta therm}{100\ ft^2} \times \frac{AFUE_{baseline}}{AFUE_{part}} \times \left[\frac{\overline{Eff}_{dist,baseline}}{\overline{Eff}_{dist,part}}\right]_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
EER	= Energy efficiency ratio under peak conditions
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
AFUE	= Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
baseline	= Baseline condition or measure
part	= Participant
dist	= Distribution
heating	= Heating
cooling	= Cooling
pk	= Peak
$\overline{Eff}$	= Average energy efficiency (0 -100%)
Eff	= Energy efficiency (0 -100%)

[517] ENERGY STAR® Product Specification Residential Windows, Doors, and Skylights, Eligibility Criteria, V6.0, January 2014

ft^2 = Glazing area (in ft^2)

Summary of Variables and Data Sources[518]

Variable	Value	Notes
ft^2		Glazing area rom application
$\Delta kWh/100\ ft^2$		Electricity consumption savings per 100 square feet of glazing area, lookup by building type and city, use existing window type or vintage default for baseline.
$\Delta kW/100\ ft^2$		Electricity demand savings per 100 square feet of glazing area, lookup by building type and city, use existing window type or vintage default for baseline.
$\Delta therm/100\ ft^2$		Gas consumption impact per 100 square foot of glazing, lookup by building type and city, use existing window type or vintage default for baseline.
$EER_{baseline}$	11.2	EER used in the simulations[519]
EER_{part}		EER of cooling systems within participant population, defaults to $EER_{baseline}$ (no adjustment)
$SEER_{baseline}$	14	SEER used in the simulations[520]
$SEER_{part}$		SEER of cooling system within participant population, defaults to $SEER_{baseline}$ (no adjustment)
$AFUE_{baseline}$	0.80	AFUE used in the simulations[521]
$AFUE_{part}$		AFUE of heating system within participant population, defaults to $AFUE_{baseline}$ (no adjustment)
$\overline{Eff}_{dist,baseline}$	0.956	Distribution system seasonal efficiency used in simulations
$\overline{Eff}_{dist,part}$		Distribution system seasonal efficiency within participant population, defaults to $\bar{\eta}_{dist,baseline}$ (no adjustment)
$Eff_{dist,pk,baselin}$	0.956	Distribution system efficiency under peak conditions used in simulation
$Eff_{dist,pk,part}$		Distribution system efficiency under peak conditions within participant population defaults to $\eta_{dist,pk,baseline}$ (no adjustment)
CF	NYC: 0.822 Elsewhere: 0.477	

Unit energy and demand savings calculated from the building prototype simulation models are shown in Appendix F. The savings are tabulated by location, building type, and HVAC system type for a variety of combinations of existing window and improved window types.

518 Due to schedule of revisions, values specified here may not align with those presented throughout appendices.
519 ECCCNYS 2016, Table C403.2.3(1) – Assumes a 5-ton packaged AC.
520 Ibid.
521 ECCCNYS 2016, Table C403.2.3(5) – Assumes a 150 kBTU/h gas boiler.

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 0.822 for NYC and 0.477 elsewhere.[522].

Baseline Efficiencies from which Savings are Calculated

A variety of existing window combinations are shown in the unit savings tables, including single pane clear glass, double pane clear glass and a minimally code compliant window. Energy savings are estimated based on the characteristics of the existing window. Single pane clear glass is the default for the old vintage, while double pane clear glass is the default for the average vintage. The minimally code compliant window as assumed to be the base case for new construction or window replacement projects.

Compliance Efficiency from which Incentives are Calculated

A typical window meeting the current ENERGY STAR® specifications is assumed to be the installed measure. The specifications assumed are listed below[523]:

U-Factor (BTU/h-ft^2-°F)	Solar Heat Gain Coefficient (SHGC)
≤0.27	Any
0.28	≥0.32
0.29	≥0.37
0.30	≥0.42

Operating Hours

The energy savings for windows are dependent on the HVAC system operating hours and thermostat set points. See Appendix A for the modeling assumptions for each building prototype.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

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

[523] ENERGY STAR® Product Specification Residential Windows, Doors, and Skylights, Eligibility Criteria, V6.0, January 2014

References

1. ENERGY STAR® Product Specification Residential Windows, Doors, and Skylights, Eligibility Criteria, Version 6.0, January 2014
   Available from:
   https://www.energystar.gov/sites/default/files/ES_Final_V6_Residential_WDS_Spec.pdf
2. ECCCNYS 2016, per IECC 2015; Table C403.2.3(1): Minimum Efficiency Requirements: Electrically Operated Unitary Air Conditioners And Condensing Units & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers. Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
3. Window properties for baseline windows taken from 2013 ASHRAE Handbook of Fundamentals Chapter 15.
4. *C&I Unitary HVAC Load Shape Project Final Report*, KEMA, August 2, 2011, Table 0-5; (accessed March 21, 2017).
   Available from:
   http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2.pdf

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1	10/15/2010
6-17-9	6/30/2017

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COMPRESSED AIR

AIR COMPRESSOR

Measure Description

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
hp_{comp}		From application
(ΔkW/hp)		Lookup in table below based o compressor size and control strategy. [524]
hrs		From application
CF	0.8	

Air Compressor Deemed Savings (ΔkW/hp)

Control type	Compressor hp	ΔkW/hp
Variable Frequency Drive	≥ 15 and < 25	0.207
Variable Frequency Drive	≥ 25 and < 75	0.206
Variable Displacement	≥ 50 and < 75	0.116

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8[525]

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

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

References

N/A

Record of Revisions

Record of Revision Number	Issue Date
1	10/15/2010
12-17-9	12/31/2017

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AIR DRYER - REFRIGERATED

Measure Description

This measure covers the installation of a cycling or variable frequency drive (VFD)-controlled refrigerated air dryer on a compressed air system with a non-cycling air dryer. High efficiency air dryers utilize a refrigeration system to condense and remove moisture from a compressed air system. As demand requires, cycling refrigerated air dryer systems cool a medium that cools the compressed air. VFD-controlled refrigerated air dryer systems use a variable speed drive as required by the demand. Both systems save energy by dismissing the need for the system to run continuously at full speed.

This measure is applicable to single compressor systems only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times CFM_{dryer} \times (\Delta kW/CFM) \times hrs$$

Peak Coincident Demand Savings

$$\Delta kW = units \times CFM_{dryer} \times (\Delta kW/CFM) \times F_{peak} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
CFM_{dryer} = Full flow rated capacity of refrigerated air dryer, in cubic feet per minute
ΔkW/CFM = kW reduction per full flow rated CFM
hrs = Annual operating hours of dryer
F_{peak} = Peak operation factor; binary variable to indicate whether equipment operates during electric system peak (summer weekday hour ending at 5PM)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
CFM_{dryer}		From application.
ΔkW/CFM	0.00554	DNV-GL.[526]

[526] Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV GL, October 2015, Table 1-10: Dryer kW per CFM Saved

Variable	Value	Notes
hrs		From application.
F_{peak}	Peak Operation: 1 No Peak Operation: 0	From application.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[527]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a compressed air system equipped with a non-cycling air dryer.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a compressed air system with a cycling or VFD-controlled refrigerated air dryer.

Operating Hours

Hours of operation shall be taken from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV-GL, prepared by KEMA, Inc. for Massachusetts Energy Efficiency Advisory Council, October 2015
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

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

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-8	6/26/2018

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ENGINEERED AIR NOZZLE

Measure Description

This measure covers the installation of engineered nozzles used in compressed air systems, for the purposes of equipment cleaning, cooling, drying, etc. Unlike standard air nozzles, engineered nozzles entrain compressed air with surrounding air to provide effective air nozzle action while reducing compressed air requirement.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (CFM_{baseline} - CFM_{ee}) \times (kW/CFM) \times hrs$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
$CFM_{baseline}$ = Open nozzle flow
CFM_{ee} = Engineered nozzle flow
kW/CFM = Air compressor kW per CFM air delivery at 100 psi
hrs = Annual hours of use of compressed air
F_{peak} = Peak operation factor; binary variable to indicate whether equipment operates during electric system peak (summer weekday hour ending at 5 PM)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
$CFM_{baseline}$	CFM = 14.485 x D^2 x (psig + 14.7)	From application, where: D = Diameter of open air nozzle orifice in inches psig = Air pressure at nozzle[528]
CFM_{ee}		From application

[528] Compressed Air Best Practices, Compressed Air Savings with Nozzles and Blowers. The constant 14.485 is a derived constant to satisfy the equation assuming air at standard temperature and pressure. The constant 14.7 converts gauge pressure (psig) into absolute pressure (psia).

Variable	Value	Notes
kW/CFM		Look up from Air Compressor Efficiency table below based on air compressor type
hrs		From application. If unknown, assume compressed air application (i.e. operation of nozzle) represents 5% of the total operating hours of the air compressor system.[529]
F_{peak}	Peak Operation: 1 No Peak Operation: 0	From application.
CF	0.8	

Air Compressor Efficiency[530]

Air Compressor Type	kW/CFM
Single-Acting, Air-Cooled Reciprocating	0.22
Double-Acting Water-Cooled Reciprocating	0.15
Lubricant-Injected Rotary Screw Compressor	0.15
Lubricant-Free Rotary Screw Compressor	0.17
Centrifugal Air Compressor	0.16
VSD Compressor	0.14[531]

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[532]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a modulating compressor with blow down system with an open/standard nozzle.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a modulating compressor with blow down system installed with an engineered nozzle, also known as an air entraining nozzle, as defined in the Measure Description section above.

Operating Hours

Nozzles are assumed to be in use 5% of the time the compressed air system is operating, if actual

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529 Assume 5% based on an average of 3 seconds per minute. Assumes 50% handheld air guns and 50% stationary air nozzles. Manual air guns tend to be used less than stationary air nozzles, and a conservative estimate of 1 second of blow-off per minute of compressor runtime is assumed. Stationary air nozzles are commonly more wasteful, as they are often mounted on machine tools and can be manually operated, resulting in the possibility of a long-term open blow situation. An assumption of 5 seconds of blow-off per minute of compressor runtime is used.

530 Improving Compressed Air System Performance: A Sourcebook for Industry, pg 46, 47.

531 Compressed Air Best Practices, VSD Compressor Control. Calculated based on operating point conditions and assuming a main-drive motor with a typical efficiency of 92%.

532 *No source specified – update pending availability and review of applicable references.*

hours of use are not known. Compressor system operating hours shall be taken from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Compressed Air Best Practices, Compressed Air Savings with Nozzles and Blowers
   Available from: https://www.airbestpractices.com/system-assessments/end-uses/compressed-air-savings-nozzles-or-blowers
2. Compressed Air Best Practices, VSD Compressor Control
   Available from: https://www.airbestpractices.com/technology/compressor-controls/vsd-compressor-control

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
9-18-11	9/28/2018

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No Air Loss Water Drain

Measure Description

This measure covers the installation of a no air loss water drain in a compressed air system. No-loss drains monitor condensate levels and allow water to drain from the compressed air system without compressed air loss. No loss drains decrease air demand and increase overall efficiency.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times CFM_{drain} \times \Delta CFM \times (kW/CFM) \times hrs$$

Peak Coincident Demand Energy Savings

$$\Delta kW = units \times CFM_{drain} \times \Delta CFM \times (kW/CFM) \times F_{peak} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
CFM_{drain} = Full flow rated capacity of drain, in cubic feet per minute
ΔCFM = Average cubic foot per minute saved per CFM of capacity of drain
kW/CFM = Air compressor kW per CFM air delivery at 100 psi
hrs = Annual operating hours
F_{peak} = Peak operation factor; binary variable to indicate whether equipment operates during electric system peak (summer weekday hour ending at 5PM)
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
CFM_{drain}		From application, if unknown, use 103.9 as default[533]

[533] Based on an orifice size of 1/4 inch and a typical system pressure of 100 psi. Orifice sizes for timed drains range from 5/32 in. to 9/16 in. with the most common size being 7/16 in; 1/4 in. is considered a reasonably conservative estimate of average size. 100 psi is a conservative estimate of average system pressure; most systems are run at higher pressure than 100 psi. 103.9 is derived using the equation CFM = 14.485 x D^2 x (psig + 14.7), where 14.485 is a derived constant to satisfy the equation assuming air at standard temperature and pressure, D is the orifice diameter in inches, psig is the air pressure at the nozzle (gauge pressure), and 14.7 converts gauge pressure into absolute pressure.

Variable	Value	Notes
ΔCFM	0.049	DNV-GL[534]
kW/CFM		Look up from Air Compressor Efficiency table below based on air compressor type
hrs		From application
F_{peak}	Peak Operation: 1 No Peak Operation: 0	From application
CF	0.8	

Air Compressor Efficiency[535]

Air Compressor Type	kW/CFM
Single-Acting, Air-Cooled Reciprocating	0.22
Double-Acting Water-Cooled Reciprocating	0.15
Lubricant-Injected Rotary Screw Compressor	0.15
Lubricant-Free Rotary Screw Compressor	0.17
Centrifugal Air Compressor	0.16
VSD Compressor[536]	0.14

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[537]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a compressed air system with an electronic solenoid and timed drain.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a load/unload with storage, VSD, or variable displacement compressed air system with a no air loss water drain.

Operating Hours

Hours of operation shall be taken from application.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

534 Impact Evaluation of Prescriptive Chiller and Compressed Air Installations, DNV GL, October 2015, p 45
535 Improving Compressed Air System Performance: A Sourcebook for Industry, pg 46, 47.
536 Compressed Air Best Practices, VSD Compressor Control. Calculated based on operating point conditions and assuming a main-drive motor with a typical efficiency of 92%.
537 *No source specified – update pending availability and review of applicable references.*

Ancillary Electric Savings Impacts

N/A

References

1. Impact Evaluation and Prescriptive Chiller and Compressed Air Installations, DNV-GL, prepared by KEMA, Inc. for Massachusetts Energy Efficiency Advisory Council. October 2015.
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf
2. Improving Compressed Air System Performance: A Sourcebook for Industry Third Edition, Department of Energy
   Available from: https://www.energy.gov/sites/prod/files/2016/03/f30/Improving%20Compressed%20Air%20Sourcebook%20version%203.pdf
3. Compressed Air Best Practices, VSD Compressor Control
   Available from: https://www.airbestpractices.com/technology/compressor-controls/vsd-compressor-control

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
9-18-12	9/28/2018

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DOMESTIC HOT WATER

INDIRECT WATER HEATER

Measure Description

This measure covers the installation of a gas-fired indirect water heater in which the stored water is heated via hot water or steam produced by a gas boiler rather than direct input from electric elements or gas burners. In such a system, a heat exchanger separates the potable water in the water heater from the boiler water. This measure applies to small commercial indirect systems comprising a boiler with input heating capacity less than 300,000 BTU/h and greater than or equal to 4,000 BTU/h per gallon of stored water.[538]

This measure estimates savings associated with the delivery of potable hot water only and assumes the installation of zone priority controls to interrupt demand for space heating until domestic hot water demand is met. Larger equipment as well as equipment where zone priority control is not feasible shall be treated under a custom application.

The baseline assumption for indirect water heaters is a minimally code compliant tank type water heater or an indirect system with a minimally code compliant boiler, based on actual existing conditions. For new construction, a tank type baseline shall be assumed.

Method for Calculating Annual Energy and Peak Coincidence Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) + \left(\frac{UA_{baseline}}{Eff_{baseline}} - \frac{UA_{ee}}{Eff_{ee}}\right) \times \frac{\Delta T_{amb}}{100{,}000} \times 8{,}760\right]$$

where:

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

538 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
Eff = Efficiency
UA = Overall heat loss coefficient (BTU/h-°F)
365 = Days in one year
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU
8,760 = Hours in one year

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}		Water heater set point temperature (°F), per application or use 140°F as a default.[539]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city. (°F).
T_{amb}	70	Surrounding ambient air temperature (°F).[540]
$Eff_{baseline}$		Efficiency of baseline condition. Lookup in Baseline Efficiencies section below.
Eff_{ee}		Efficiency of energy efficient indirect-system boiler (AFUE) from application.
$UA_{baseline}$		Overall heat loss coefficient of the baseline condition (BTU/h-°F). Calculate based on baseline standby loss per the Baseline Heat Loss Coefficient section below.
UA_{ee}		Overall heat loss coefficient of the energy efficient measure (BTU/h-°F). Calculate based on energy

539 Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
540 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.

Variable	Value	Notes
		efficient standby loss per the Qualifying Heat Loss Coefficient section below.

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[541]: 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[542]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation[543]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC[544]: 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

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

City	Annual average outdoor temperature[546] (°F)	T_{main} (°F)
Albany	48.3	54.3

[541] 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

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

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

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

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

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

City	Annual average outdoor temperature[546] (°F)	T_{main} (°F)
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

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

$UA_{baseline}$ is calculated from the assumed equipment standby loss specification ($SL_{baseline}$), which is determined per minimum effective federal standards for commercial gas storage type water heaters (see Baseline Standby Losses section below).[547]

$$UA_{baseline} = \frac{SL_{baseline}}{70}$$

where:

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

70 = Temperature difference associated with standby loss specification (°F)[548]

Baseline Standby Losses ($SL_{baseline}$)

Standby losses ($SL_{baseline}$) for commercial gas storage type water heaters:[549]

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

where:

$v_{baseline}$ = Baseline tank volume (gal), equal to the storage capacity of the efficient equipment

$Q_{baseline}$ = Baseline input capacity (BTU/h), equal to the input capacity of the efficient equipment

Qualifying Heat Loss Coefficient (UA_{ee})

Indirect water heater storage tanks are tested and rated for standby losses (in °F/hr or BTU/h) at standard testing conditions in accordance with testing standards.[550]

547 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

548 Ibid.

549 Ibid.

550 GAMA Testing Standard: Performance of Indirect-Fired Water Heaters, March 2003

For equipment with standby losses rated in °F/hr, the qualifying equipment standby loss specification (SL_{ee}) shall be used in the formula below, along with tank volume (v_{ee}) to establish the qualifying equipment heat loss coefficient (UA_{ee}).

$$UA_{ee} = \frac{SL_{ee}}{70} \times v_{ee} \times 8.33$$

where:

UA_{ee} = Overall heat loss coefficient (BTU/h-°F) of the energy efficient condition or measure
SL_{ee} = Standby loss specification (°F/hr) of the energy efficient condition or measure
v_{ee} = Rated storage capacity (gallons) of the energy efficient condition or measure
70 = Temperature difference associated with standby loss specification (°F)[551]
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit

For equipment with standby losses rated in BTU/h, the qualifying equipment standby loss specification (SL_{ee}) shall be used in the formula below to establish the qualifying equipment heat loss coefficient (UA_{ee})

$$UA_{ee} = \frac{SL_{ee}}{70}$$

where:

UA_{ee} = Overall heat loss coefficient (BTU/h-°F) of the energy efficient condition or measure
SL_{ee} = Standby loss specification (BTU/h) of the energy efficient condition or measure
70 = Temperature difference associated with standby loss specification (°F)[552]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a minimally code compliant gas storage type or indirect water heater (based on actual existing conditions) with efficiency per the Energy Conservation Construction Code of New York State[553] and the New York City Energy Conservation Code[554] as shown in the table below. Heat loss coefficient of the baseline condition shall be established as indicated in the Baseline Heat Loss Coefficient section above. Measure is only applicable to small commercial (<300,000 BTU/h) equipment in applications with zone priority control. Baseline tank volume and

[551] 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
[552] Ibid.
[553] ECCCNYS 2016, Table C403.2.3(5) and Table C404.2
[554] NYCECC 2016, Table C403.2.3(5) and Table C404.2

input capacity shall be set equal to the energy efficient condition. For new construction, a tank type baseline shall be assumed.

Equipment Type/Size	Efficiency
Tank Type: All Sizes	0.80 E_t
Gas Boiler: < 300,000 BTU/h	0.80 AFUE
Steam Boiler, All Except Natural Draft: < 300,000 BTU/h	0.75 AFUE
Steam Boiler, Natural Draft: < 300,000 BTU/h	0.75 AFUE

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a small commercial (<300,000 BTU/h) gas-fired indirect water heater meeting minimum performance requirements as dictated by program eligibility criteria in applications with zone priority control.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

References

1. 10 CFR 431.102 Definitions concerning commercial water heaters, hot water supply boilers, unfired hot water storage tanks, and commercial heat pump water heaters. Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=863517ec5f69fb78dad68864aa84c128&mc=true&n=sp10.3.431.g&r=SUBPART&ty=HTML#se10.3.431_1102
2. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems Available from: https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html

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1	10/15/2010
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STORAGE TANK WATER HEATER

Measure Description

This measure covers the installation of gas and electric storage tank water heaters designed to heat and store water at a thermostatically controlled temperature. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating.

Storage type units include commercial gas storage water heaters with a nominal input of greater than 75,000 BTU/h and less than 4,000 BTU/h per gallon of stored water and commercial electric storage water heaters with a nominal input of greater than 12 kilowatts and less than 4,000 BTU/h per gallon of stored water.[555]

This measure applies to replacement of existing storage type water heaters using the same heating fuel (gas 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 (gas or electric) as the efficient equipment.

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 (Electric Equipment Only)

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

Peak Coincident Demand Savings (Electric Equipment Only)

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

Annual Gas Energy Savings (Gas Equipment Only)

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

where:

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

[555] 10 CFR 431.102

GPD = Gallons per day
ΔT_{main} = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb} = Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
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
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 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}		Water heater set point temperature (°F), per application or use 140°F as a default.[556]
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).[557]
$E_{t,baseline}$	Electric: 0.98 Gas: 0.80	Thermal efficiency of the baseline condition[558,559]
$E_{t,ee}$		Thermal efficiency for energy efficient measure, from application

[556] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
[557] 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.
[558] Gas: 10 CFR 431.110 (a)
[559] 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*

Variable	Value	Notes
$UA_{baseline}$		Overall heat loss coefficient of the baseline condition (BTU/h-°F). Calculate based on baseline standby loss per the Overall Heat Loss Coefficient section below.
UA_{ee}		Overall heat loss coefficient of the energy efficient measure (BTU/h-°F). Calculate based on energy efficient standby loss per the Overall Heat Loss Coefficient section below.
CF	0.8	

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[560]: 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[561]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation[562]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC[563]: 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

[560] 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
[561] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011
[562] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016
[563] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

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

City	Annual average outdoor temperature[565] (°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

Overall Heat Loss Coefficient ($UA_{baseline}$ and UA_{ee})
Tank overall heat loss coefficient is calculated from the equipment standby loss specification. For UA_{ee}, the manufacturer specified standby loss shall be applied directly to the UA formula below. 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), from application for the energy efficient measure (SL_{ee}). 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)[566]

Baseline Standby Losses ($SL_{baseline}$)
Standby losses ($SL_{baseline}$) for commercial electric storage type water heaters:[567]

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

where:

$v_{baseline}$ = Baseline tank volume (gal), equal to the storage capacity of the efficient equipment

[564] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[565] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals
[566] 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
[567] Ibid.

Standby losses ($SL_{baseline}$) for commercial gas storage type water heaters:[568]

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

where:

$v_{baseline}$ = Baseline tank volume (gal), equal to the storage capacity of the efficient equipment
$Q_{baseline}$ = Baseline input capacity (BTU/h), equal to the input capacity of the efficient equipment

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8[569]

Baseline Efficiencies from which Savings are Calculated

The baseline condition for replacement measures is a standard efficiency gas or electric storage type water heater (based on proposed conditions) with tank volume and input capacity equivalent to the efficient case, UA value calculated as prescribed above and a thermal efficiency of 0.80 (gas) or 0.98 (electric).

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a gas or electric storage type water heater as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

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.

Ancillary Fossil Fuel Savings Impacts

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

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568 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

569 *No source specified – update pending availability and review of applicable references.*

Ancillary Electric Savings Impacts

High-efficiency water heaters may incorporate a draft fan, which increases electricity consumption. Additionally, reduction in standby heat losses will have a negligible impact on space heating and cooling when the water heater is located in conditioned space. Consideration of these effects is not included in this methodology.

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2. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems Available from: https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
3. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
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11. 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters
Available from:
https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
12-17-10	12/31/2017

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INSTANTANEOUS WATER HEATER

Measure Description

This measure covers the installation of high-efficiency gas 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 gas-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.[570] 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 (gas 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 (gas 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

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \left[\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}}\right) + \frac{UA_{baseline} \times \Delta T_{amb} \times 8{,}760}{E_{t,baseline} \times 100{,}000}\right]$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
GPD = Gallons per day
ΔT_{main} = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)
ΔT_{amb} = Average temperature difference between water heater set point temperature and

[570] 10 CFR 431.102

	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
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 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.[571]
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). [572]
$E_{t,baseline}$	Electric: 0.98 Gas: 0.80	Thermal efficiency of the baseline condition[573,574]
$E_{t,ee}$		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	

[571] Per OSHA recommendations for prevention of Legionella bacterial growth (https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html)
[572] 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.
[573] Gas: 10 CFR 431.110 (a)
[574] 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[575]: 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[576]: School with Showers
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation[577]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School
Fast Food Restaurant	500	500 GPD per restaurant		FSTC[578]: 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.[579] Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature[580] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5

575 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

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

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

580 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

City	Annual average outdoor temperature[580] (°F)	T_{main} (°F)
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)[581]

Baseline Standby Losses ($SL_{baseline}$)

Standby losses ($SL_{baseline}$) for large electric storage type water heaters (> 12kW and > 20 gallons):[582]

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

where:

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

Standby losses ($SL_{baseline}$) for large gas storage type water heaters (> 75,000 BTU/h input capacity (Q) and storage size > 1 gallon per 4000 BTU/h):[583]

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

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.

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[581] 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

[582] Ibid.

[583] Ibid.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8[584]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard efficiency gas 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 (gas) or 0.98 (electric). If tank volume and input capacity are unknown, assume the baseline condition consists of a 150-gallon storage type water heater with an input capacity of 200,000 BTU/h.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a gas or electric instantaneous water heater as defined in the Measure Description section above. Gas tankless water heaters must meet the minimum qualifying efficiency for ENERGY STAR® certification of a thermal efficiency greater than or equal to 0.94.[585] 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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[584] *No source specified – update pending availability and review of applicable references.*
[585] ENERGY STAR® Commercial Water Heater Key Product Criteria

References

1. 10 CFR 431.102 Definitions concerning commercial water heaters, hot water supply boilers, unfired hot water storage tanks, and commercial heat pump water heaters. Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=863517ec5f69fb78dad68864aa84c128&mc=true&n=sp10.3.431.g&r=SUBPART&ty=HTML#se10.3.431_1102
2. OSHA Legionnaire's Disease eTool: Section II: C-1. Domestic Hot-Water Systems Available from: https://www.osha.gov/SLTC/legionnairesdisease/control_prevention.html
3. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
4. 10 CFR 431.110 Energy conservation standards and their effective dates Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=64f994924a5f31b841cab23a6d543f85&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1110
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7. Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016 Available from: http://www.waterrf.org/PublicReportLibrary/4309A.pdf
8. Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010 Available from: https://fishnick.com/design/waterheating/Water_Heating_Design_Guide_Final_FNi_disclaimer.pdf
9. Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory. Available from: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.515.6885
10. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
11. 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters Available from: https://energy.gov/sites/prod/files/2016/08/f33/Water%20Heaters%20Test%20Procedure%20SNOPR.pdf

12. ENERGY STAR® Commercial Water Heater Key Product Criteria
Available from: https://www.energystar.gov/products/water_heaters/commercial_water_heaters/key_product_criteria

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DOMESTIC HOT WATER (DHW) – CONTROL

FAUCET – LOW-FLOW AERATOR

Measure Description

This measure covers the installation of low-flow faucet aerators in commercial and industrial applications. A faucet aerator is a water saving device that attaches to a preinstalled faucet and reduces water flow while maintaining appropriate water pressure. Retrofitting existing code compliant aerators in locations where service water is supplied by electric or natural gas fired hot water heaters with more energy efficient aerators reduces hot water consumption resulting in corresponding energy savings. This measure is not applicable to public lavatories.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{\left(GPM_{baseline} \times Flow_{r,baseline} - GPM_{ee} \times Flow_{r,ee}\right) \times \Delta T_{main} \times 8.33}{3{,}412} \times 60 \times hrs \times days \times \frac{1}{E_{t,elec}}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therm = units \times \frac{\left(GPM_{baseline} \times Flow_{r,baseline} - GPM_{ee} \times Flow_{r,ee}\right) \times \Delta T_{main} \times 8.33}{100{,}000} \times 60 \times hrs \times days \times \frac{1}{E_{t,gas}}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
GPM	= Gallons per minute
$Flow_r$	= Flow rate restricted
ΔT_{main}	= Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F)
hrs	= Operating hours per day
days	= Operating days per year

E_t = Water heater thermal efficiency
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
60 = Conversion factor, minutes in one hour
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$	Kitchen Sink: 2.2 Private Lavatory: 1.5	Maximum flow rate defined by NYS[586] and NYC[587] plumbing code. For municipalities subject to EPA WaterSense (i.e., WaterSense Partners[588]), maximum standard flow rate under that program supersede federal standard values.
GPM_{ee}		From application, or use minimum program compliant flowrate if unknown.
$Flow_{r,baseline}$	0.83	American Council for an Energy-Efficiet Economy. [589]
$Flow_{r,ee}$	0.95	American Council for an Energy-Efficiet Economy. [590]
hrs	0.25	Based on an assumed 30 uses per day, 30 seconds per use.[591]
days		Facility annual operating days, from application or look up based on facility type in Operating Hours section below.
ΔT_{main}	$T_{faucet} - T_{main}$	Average temperature difference between faucet operating temperature and the supply water temperature in water main (°F).
T_{faucet}	Lavatory: 86 Kitchen: 93 Unknown: 88	Faucet operating temperature (°F).[592] Unknown is derived from the calculated weighted average based on statewide average assumptions: ((1*93)+(3*86))/(1+3)=88.
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.

586 2017 NYS Uniform Code Supplement, Table P2903.2
587 2014 NYC Plumbing Code, Table 604.4
588 Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory
589 Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008, pg. 1-265
590 Ibid.
591 FEMP, Domestic Water Conservation Technologies, pg. 35
592 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, Directed to Michigan Evaluation Working Group. Table 93 “HEI Updated PY2014 Variable Assumptions”

Variable	Value	Notes
$E_{t,elec}$	0.98	Thermal efficiency of electric water heater.[593]
$E_{t,gas}$	0.80	Thermal efficiency of gas water heater. [594]

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

City	Annual average outdoor temperature[596] (°F)	T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor

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

Baseline Efficiency from Which Savings are Calculated

The baseline condition is a kitchen sink or private lavatory faucet aerator as defined in the Measure Description section above with flow rate equivalent to maximum code compliant GPM per application.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a low-flow kitchen sink or private lavatory faucet aerator as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

Faucets are assumed to be used 30 times per day with an average of 30 seconds per use.[597] Days of operation shall be taken from application. If unknown, default operating days per year are

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593 Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*

594 Per 10 CFR 431.110 (a)

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

596 Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

597 FEMP, Domestic Water Conservation Technologies, pg. 35

provided below, established based on a weighted average of values associated with similar facility types, as reported by the California Energy Commission.[598]

Facility Type	Days/Year
Community College	283
Fast Food	363
Full Service Restaurant	321
Grocery	365
Hospital	365
Hotel	365
Miscellaneous	325
Motel	365
Primary School	180
Secondary School	180
Small Office	250
University	283

Effective Useful Life

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
   Available from: http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
3. Energy-related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008
   Available from: http://www.seattle.gov/light/conserve/reports/paper_10.pdf

[598] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E.

4. Federal Energy Management Program, Domestic Water Conservation Technologies, October 2002
   Available from: https://www1.eere.energy.gov/femp/pdfs/22799.pdf
5. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, Directed to Michigan Evaluation Working Group
   Available from: http://www.oracle.com/us/industries/utilities/cadmus-indianapolis-power-light-3697534.pdf
6. 10 CFR 430 Subpart B – Test Procedures, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters
   Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9624a8ba0987aaae248454c49194a661&mc=true&n=pt10.3.430&r=PART&ty=HTML#ap10.3.430_127.e
7. 10 CFR 431.110 Energy conservation standards and their effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=64f994924a5f31b841cab23a6d543f85&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1110
8. Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
   Available from: https://energy.mo.gov/sites/energy/files/algorithmformainswatertemperature.pdf
9. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
10. California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014.
    Available from: http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

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1	10/15/2010
6-18-9	6/26/2018

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Low-Flow Salon Valves

Measure Description

This measure covers the retrofit of salon valves, often used at hair salons and at pet grooming facilities, with low-flow spray heads. Salon valves are handheld devices that are designed to wash and rinse hair. Retrofitting existing standard-flow salon valves in locations where service water is supplied by electric or natural gas fired hot water heaters with new low-flow heads reduces hot water consumption, which results in corresponding energy savings.

Due to limited information regarding the typical operating characteristics of low-flow salon valves, this measure relies on commercial showerhead and pre-rinse spray valve research to establish an approach that estimates the savings associated with low-flow salon valve devices.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Water Heating Equipment Only)

$$\Delta kWh = units \times \frac{(GPM_{baseline} - GPM_{ee}) \times F_{throttle} \times min_{valve} \times hrs \times \Delta T_{main} \times 8.33}{3{,}412} \times \frac{1}{Eff_{elec}}$$

Peak Coincident Electrical Demand Savings (Electric Water Heating Equipment Only)

$$\Delta kW = N/A$$

Annual Gas Energy Savings (Gas Water Heating Equipment Only)

$$\Delta therms = units \times \frac{(GPM_{baseline} - GPM_{ee}) \times F_{throttle} \times min_{valve} \times hrs \times \Delta T_{main} \times 8.33}{100{,}000} \times \frac{1}{Eff_{gas}}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
GPM	= Gallons per minute
$F_{throttle}$	= Throttle factor
min_{valve}	= Minutes of operation of salon valve per hour
hrs	= Annual operating hours of facility
ΔT_{main}	= Average temperature difference between salon valve operating temperature and the supply water temperature in water main (°F)

Eff = Water heating process efficiency
8.33 = Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kWh equals 3,412 BTU
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$	NYS: 2.5 NYC: 2.0 WaterSense®: See Notes	Current international plumbing code standard as adopted by New York State[599] and New York City.[600] For municipalities subject to EPA WaterSense® (i.e., WaterSense Partners[601]), showerheads under that program shall follow code-compliant values.[602]
GPM_{ee}		From application.
$F_{throttle}$	0.9	Used in LBNL study to adjust for occupant reduction in flowrate[603]
min_{valve}	20	One shampoo cycle lasts 5 minutes and occurs an average of 4 times per washing station per hour, based on market research.
hrs		From application. If unknown, use 2,080.[604]
ΔT_{main}	$T_{valve} - T_{main}$	Average temperature difference between valve operating temperature and the supply water temperature in water main (°F).
T_{valve}		Salon valve operating temperature (°F), from application. If unknown, assume 105°F.[605]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
Eff_{elec}	0.90	Process efficiency of electric water heater.[606] The temperature differential is derived from the average main temperature and the operating temperature at the valve. Therefore, process efficiency of delivery of hot water to the valve, rather than rated water heater efficiency, is used.

[599] 2016 NYS Plumbing Code, Table 604.4
[600] 2014 NYC Plumbing Code, Table 604.4
[601] Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory
[602] EPA WaterSense® Specification for Showerheads, Version 1.1, July 26, 2011
[603] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[604] Based on market research, assumes 5 minutes of water used per shampoo and 4 shampoos per hour where facility operating hours are 8 hours per day, 5 days per week.
[605] Average temperature at showerhead; conservative assumption based on NYS plumbing code, EPA MFHR program and ASSE 1070-2014
[606] EPA Water Sense Pre-Rinse Spray Valves Field Study Report, February 2011, pg. 30

Variable	Value	Notes
Eff_{gas}	0.60	Process efficiency of gas water heater.[607] The temperature differential is derived from the average main temperature and the operating temperature at the valve. Therefore, process efficiency of delivery of hot water to the valve, rather than rated water heater efficiency, is used.

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

City	Annual average outdoor temperature[609] (°F)	Average Main Temperature T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is N/A.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a salon valve as defined in the Measure Description section above with flow rate equivalent to maximum code compliance. For municipalities subject to EPA WaterSense (i.e., WaterSense Partners), maximum standard flowrates under that program supersede code compliant values.[610]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a salon valve as defined in the Measure Description section above with flow rate less than the specified baseline value (< 2.0 gpm) or less than the more restrictive codes or guidelines of local governments, municipalities or entities which, for example, participate in the US EPA Water Sense® Partnership Program.

[607] EPA Water Sense Pre-Rinse Spray Valves Field Study Report, February 2011, pg. 30
[608] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[609] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals.
[610] Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory

Operating Hours

Based on market research, one shampoo cycle lasts 5 minutes and occurs an average of 4 times per washing station per hour, resulting in 20 minutes of valve operation per hour. Total annual hours of usage are based on the hours of operation of the facility, from application. If unknown, assume 2,080 annual hours, based on 8 hours per day, 5 days per week.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYS Plumbing Code 2016, per 2015 International Plumbing Code, Chapter 6
   Available from: https://codes.iccsafe.org/public/document/IPC2015NY/chapter-6-water-supply-and-distribution
2. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
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   Available from: https://www.epa.gov/sites/production/files/2018-07/documents/ws-products-specification-showerheads-v1-1.pdf
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5. US EPA, WaterSense® Pre-Rinse Spray Valves Field Study Report, February 1, 2011
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   Available from: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.515.6885
7. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
8. CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Spray Valves

Available from:
https://library.cee1.org/system/files/library/4252/PRSV%20Program%20Guidance.pdf

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SHOWERHEAD – LOW FLOW

Measure Description

A low flow showerhead is a water saving showerhead with rated gallons per minute (gpm) less than maximum allowable flowrate as mandated by federal, state and regional code. New York City plumbing code and New York State construction code dictate a maximum flowrate of 2.0 gpm for showerheads. This is a retrofit direct install measure or a new installation.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
$H_2O_{savings}$	= Reduction of hot water usage per facility per year
units	= Number of measures installed under the program
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
GPM	= Gallons per minute
E_t	= Thermal efficiency of water heater
$Throttle_{fac}$	= Throttle factor
8.33	= Specific weight of water (lbs/gallon)
T_{shower}	= Temperature (°F) at showerhead
T_{main}	= Temperature (°F) of supply water from main
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU’s
3,412	= Conversion factor, one kW equals 3,412 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		Gallons per minute for energy efficient measure, from application.
$GPM_{baseline}$	2.0	Gallons per minute for baseline[611,612]
$Throttle_{fac}$	0.9	Used in LBNL study to adjust for occupant reduction in flow rate[613]
minutes/use	8.2	Average shower duration per LBNL study.[614]
uses/day		From application.
$E_{t,gas}$	0.80	Assumed typical gas hot water heater recovery efficiency (standard efficiency)
	0.94	Assumed typical gas hot water heater recovery efficiency (ENERGY STAR® qualified)
$E_{t,elec}$	0.98	Assumed typical electric hot water heater recovery efficiency.
T_{main}		Average inlet water temperature (°F) by location is shown below.
T_{shower}	105	Average temperature (°F) at showerhead; conservative assumption based on NYS plumbing code, EPA MFHR program and ASSE 1070-2014

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

City	Annual average outdoor temperature[616] (°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

[611] 2017 NYS Uniform Code Supplement, Table P2903.2
[612] 2014 NYC Plumbing Code, Table 604.4
[613] LBNL: Potential Water and Energy Savings from Showerheads, March 2006
[614] Ibid.
[615] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
[616] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The Summary of Variables and Data Sources provides the baseline (standard) water flow, water heating efficiency and related input assumptions. Assumptions regarding average duration of use and number of uses per day are also presented.

Compliance Efficiency from which Incentives are Calculated

Compliance flow rate is less than the specified baseline value (<2.0 gpm) or less than the more restrictive codes or guidelines of local governments, municipalities or entities which, for example, participate in the US EPA Water Sense® Partnership Program. [617]

Operating Hours

Assumed duration of shower and assumed number of showers per day as listed above in Summary of Variables and Data Sources.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
2. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
3. NYS 2017 Uniform Code Supplement, March 2017: Section 2.39 – 2015 IRC Table P2903.2 (Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings)
   Available from: https://www.dos.ny.gov/dcea/pdf/2017-Uniform-Code-Supplement-3-17-2017.pdf

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

4. NYC Plumbing Code, 2014; Table 604.4: Maximum Flow Rates and Consumption for Plumbing Fixtures and Fixture Fittings
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http://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_PC_Chapter6_Water_Supply_and_Distribution.pdf&section=conscode_2014
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1	10/15/2010
6-13-8	6/30/2013
6-15-1	6/1/2015
6-17-10	6/30/2017

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LOW-FLOW PRE-RINSE SPRAY VALVE

Measure Description

This measure covers the retrofit of pre-rinse spray valves, often used in commercial and institutional kitchens. Pre-rinse spray valves (PRSV) are handheld devices that are designed to remove food waste from dishes prior to dishwashing. Retrofitting existing standard flow PRSVs in locations where service water is supplied by electric or natural gas fired hot water heaters with new low-flow PRSVs reduces hot water consumption resulting in corresponding energy savings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Electric Water Heating Equipment Only)

$$\Delta kWh = units \times \frac{(GPM_{baseline} - GPM_{ee}) \times 60 \times hrs \times \Delta T_{main} \times 8.33}{3{,}412} \times \frac{1}{Eff_{elec}}$$

Peak Coincident Electrical Demand Savings (Electric Water Heating Equipment Only)

$$\Delta kW = N/A$$

Annual Gas Energy Savings (Gas Water Heating Equipment Only)

$$\Delta therms = units \times \frac{(GPM_{baseline} - GPM_{ee}) \times 60 \times hrs \times \Delta T_{main} \times 8.33}{100{,}000} \times \frac{1}{Eff_{gas}}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
GPM	= Gallons per minute
hrs	= Annual operating hours of PRSV
ΔT_{main}	= Average temperature difference between PRSV operating temperature and the supply water temperature in water main (°F)
Eff	= Water heating process efficiency
8.33	= Energy required (BTU) to heat one gallon of water by one degree Fahrenheit
3,412	= Conversion factor, one kWh equals 3,412 BTU
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU
60	= Minutes in one hour

Summary of Variables and Data Sources

Variable	Value	Notes
$GPM_{baseline}$	≤ 5.0 ozf: 1.00 > 5.0 and ≤ 8.0 ozf: 1.20 > 8.0 ozf: 1.28	Current federal standard based on spray force product class in ounce-force, ofz.[618] For municipalities subject to EPA WaterSense (i.e., WaterSense Partners[619]), maximum standard flowrate under that program supersede federal standard values.
GPM_{ee}		From application.
hrs		Lookup in operating hours table below based on facility type. If unknown, use 365 as default
ΔT_{main}	$T_{PRSV} - T_{main}$	Average temperature difference between PRSV operating temperature and the supply water temperature in water main (°F).
T_{PRSV}		PRSV operating temperature (°F), from application. If unknown, assume 120°F.[620]
T_{main}		Supply water temperature in water main (°F). Lookup in Cold Water Inlet Temperature table below based on nearest city.
Eff_{elec}	0.90	Process efficiency of electric water heater.[621] The temperature differential is derived from the average main temperature and the operating temperature at the PRSV. Therefore, process efficiency of delivery of hot water to the PRSV, rather than rated water heater efficiency, is used.
Eff_{gas}	0.60	Process efficiency of gas water heater.[622] The temperature differential is derived from the average main temperature and the operating temperature at the PRSV. Therefore, process efficiency of delivery of hot water to the PRSV, rather than rated water heater efficiency, is used.

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

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618 10 CFR 431.266(b)

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

620 CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Spray Valves, 2005, pg. 3

621 EPA Water Sense Pre-Rinse Spray Valves Field Study Report, February 2011, pg. 30

622 EPA Water Sense Pre-Rinse Spray Valves Field Study Report, February 2011, pg. 30

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

City	Annual average outdoor temperature[624] (°F)	Average Main Temperature T_{main} (°F)
Albany	48.3	54.3
Binghamton	46.3	52.3
Buffalo	48.3	54.3
Massena	43.5	49.5
NYC	55.4	61.4
Poughkeepsie	49.8	55.8
Syracuse	48.3	54.3

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is N/A.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a PRSV as defined in the Measure Description section above with flow rate equivalent to current federal standard. For municipalities subject to EPA WaterSense (i.e., WaterSense Partners[625]), maximum standard flowrate under that program supersede federal standard values.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a PRSV as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

Annual operating hours of pre-rinse spray valves based on facility type are listed in the table below.[626]

Type of Facility	hrs (Hours/Year)
Quick-Service Restaurant	365
Casual Dining Restaurant	730
Cafeteria	1460

Effective Useful Life (EUL)

See Appendix P.

[624] Average annual outdoor temperatures taken from NCEI 1981-2010 climate normals
[625] Find Water Sense Partners at the Environmental Protection Agency website: https://www.epa.gov/watersense/partners-directory
[626] CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Spray Valves, 2005, pg. 3

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

9. 10 CFR 431.266 Energy conservation standards and their effective dates
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=fa5acd7c1276f26b10eb66f5c415baae&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1266
10. US EPA, WaterSense® Pre-Rinse Spray Valves Field Study Report, February 1, 2011
Available from:
http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?ItemID=5534
11. Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory
Available from:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf
12. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
13. CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Spray Valves
Available from:
https://library.cee1.org/system/files/library/4252/PRSV%20Program%20Guidance.pdf

Record of Revision

Record of Revision Number	Issue Date
1-16-18	12/31/2015
3-18-10	3/29/2018

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

REFRIGERANT CHARGE CORRECTION & TUNE UP – CAC AND ASHP

Measure Description

This measure estimates savings associated with refrigerant charge correction of air-cooled central air conditioners and air source heat pumps in small commercial applications. In order to be eligible for energy savings, the scope of work performed must include manufacturer recommended AC tune-up procedures including but not limited to the cleaning of condenser coils.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For Units with Cooling Capacity < 65,000 BTU/h

$$\Delta kWh = units \times \left\{\left[tons/unit \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling}\right] + \left[(kBTU/h)_{out}/unit \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}\right]\right\}$$

For Units with Cooling Capacity ≥ 65,000 BTU/h

$$\Delta kWh = units \times \left\{\left[tons/unit \times \left(\frac{12}{IEER_{baseline}} - \frac{12}{IEER_{ee}}\right) \times EFLH_{cooling}\right] + \left[\frac{(kBTU/h)_{out}/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right]\right\}$$

Peak Coincident Demand Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
tons/unit = Tons of air conditioning per unit, based on AHRI certification or nameplate data of condenser or matched pair (condenser and coil)

$(kBTU/h)_{out}/unit$ = Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
ee = Energy efficient condition or measure
baseline = Baseline condition or measure
SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
IEER = Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions (used only for units with cooing capacity ≥ 65,000 BTU/h)
EER = Energy efficiency ratio under peak conditions, measurement of cooling capacity for a unit (in BTU/h) / electrical energy used (watts) (at AHRI standard rating conditions)
HSPF = Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP = Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$EFLH_{cooling}$ = Equivalent full-load cooling hours
$EFLH_{heating}$ = Equivalent full-load heating hours
CF = Coincidence factor
12 = (kBTU/h)/ton of air conditioning capacity
3,412 = Conversion factor, one watt-hour equals 3.412 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application
$SEER_{ee}$		Actual equipment nameplate SEER.
$SEER_{baseline}$		Actual equipment nameplate SEER, derated in accordance with the Baseline Degradation Factor section below.
$IEER_{ee}$		Actual equipment nameplate IEER.
$IEER_{baseline}$		Actual equipment nameplate IEER, derated in accordance with the Baseline Degradation Factor section below.
EER_{ee}		Actual equipment nameplate EER
$EER_{baseline}$		Actual equipment nameplate EER, derated in accordance with the Baseline Degradation Factor section below.
$HSPF_{ee}$		Actual equipment nameplate HSPF.
$HSPF_{baseline}$		Actual equipment nameplate HSPF, derated in accordance with the Baseline Degradation Factor section below.
COP_{ee}		Actual equipment nameplate COP.
$COP_{baseline}$		Actual equipment nameplate COP, derated in accordance with the Baseline Degradation Factor section below.
$EFLH_{cooling}$		From application. If unknown, look up based on building type, system type and location from Appendix G.
$EFLH_{heating}$		From application. If unknown, look up based on building type, system type and location from Appendix G.

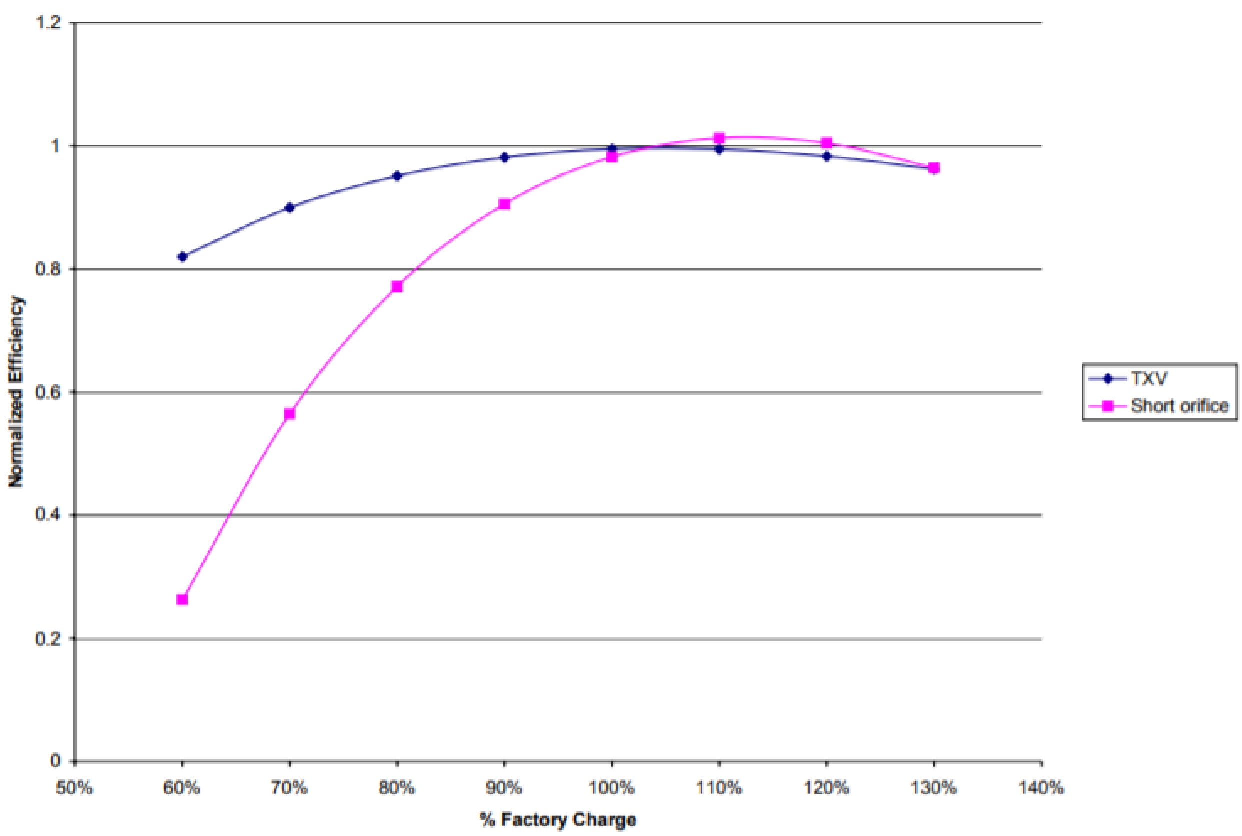
Variable	Value	Notes
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[627]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is equivalent to the existing condition with efficiency ratings taken from the equipment nameplate, derated to account for under or overcharging. The efficiency improvement resulting from refrigerant charge adjustment is dependent upon the discrepancy between the actual equipment charge before the adjustment was performed and the manufacturer's specification. The efficiency adjustment factor as a function of charge adjustment is taken from the figure or table below.[628] Note the efficiency change depends on the type of expansion valve. Use the curve or column labeled "TXV" for units with thermal expansion valves; otherwise use the curve or column labeled "Short orifice".



[627] *No source specified – update pending availability and review of applicable references.*
[628] Efficiency as a function of charge adjustment from Small HVAC System Design Guide, New Buildings Institute, 2003, pg 40

% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)	% Factory Charge	Normalized Efficiency (Short Orifice)	Normalized Efficiency (TXV)
60%	0.26	0.82	96%	0.96	0.99
62%	0.32	0.84	98%	0.97	0.99
64%	0.39	0.85	100%	0.98	1.00
66%	0.45	0.87	102%	0.99	1.00
68%	0.51	0.89	104%	1.00	1.00
70%	0.56	0.90	106%	1.00	1.00
72%	0.61	0.91	108%	1.00	1.00
74%	0.66	0.92	110%	1.00	1.00
76%	0.70	0.93	112%	1.00	0.99
78%	0.73	0.94	114%	1.00	0.99
80%	0.77	0.95	116%	1.00	0.99
82%	0.80	0.96	118%	1.00	0.99
84%	0.83	0.97	120%	1.00	0.99
86%	0.86	0.97	122%	1.00	0.98
88%	0.88	0.98	124%	0.99	0.98
90%	0.91	0.98	126%	0.98	0.97
92%	0.92	0.99	128%	0.97	0.97
94%	0.94	0.99	130%	0.96	0.96

If the equipment contains multiple refrigeration circuits, relevant baseline efficiency ratings shall be calculated by establishing the total degradation factor as the sum of each circuit's derating factor multiplied by its percentage of the total system capacity and multiplying this value by the system's nameplate efficiency. The equation for $EER_{baseline}$, for example, is shown below:

$$EER_{baseline} = EER_{ee} \times \sum_{n} (Cap_n \times Fderate_n)$$

where:

n = Each circuit

Cap = Fraction of total system capacity

Fderate = Baseline degradation factor, based on % over/undercharging from table above

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a commercial air conditioner or heat pump with corrected refrigerant charge. SEER, IEER, EER, HSPF, and COP are taken from application as reported by equipment manual.

Operating Hours

Equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type, system type and location can be found in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Small HVAC System Design Guide, New Buildings Institute, White Salmon, WA for the California Energy Commission.
Available from: http://www.energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-12.PDF

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-10	6/26/2018

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Unitary Air Conditioner and Unitary & Applied Heat Pump

Measure Description

This measure covers installation of high-efficiency unitary air conditioners and unitary and applied heat pumps in commercial applications including high rise multifamily buildings of four or more stories[629] or with an occupied floor located more than 75 feet above the lowest level of fire department vehicle access[630]. The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local code.

Unitary Air Conditioner
One or more factory-made assemblies, which normally include a cooling coil, an air moving device, a compressor(s) and condenser combination, and may include a heating function as well. The functions of commercial and industrial Unitary Air Conditioners, either alone or in combination with a heating plant, are to provide air circulation, cooling, and dehumidification, and may include the functions of heating, humidifying, outdoor air ventilation, and air cleaning.[631]

Unitary and Applied Heat Pump
One or more factory-made assemblies, which normally include an indoor conditioning coil, an air moving device, compressor(s), and an outdoor coil(s), including means to provide a heating function and may or may not include a cooling function. Such equipment may be provided in one assembly by a single manufacturer (unitary) or separate assemblies designed to be used together (applied). Commercial and industrial unitary and applied heat pumps shall provide the function of heating and may include the function of air circulation, air cooling, dehumidifying or humidifying, outdoor air ventilation, and air cleaning.[632]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For Units with Cooling Capacity <65,000 BTU/h

$$\Delta kWh = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling} + \frac{kBTU/h}{unit} \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}\right]$$

[629] NYSERDA, Mid- and High-Rise Multifamily Buildings
[630] IBC 2015; Chapter 2 Definitions: High-Rise Building
[631] AHRI Standard 340/360 – 2015 & AHRI Standard 210/240 with Addenda 1 and 2 – 2012
[632] Ibid.

For Units with Cooling Capacity ≥ 65,000 BTU/h

$$\Delta kWh = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{IEER_{baseline}} - \frac{12}{IEER_{ee}}\right) \times EFLH_{cooling} + \frac{(kBTU/h)/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right]$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF_{cooling}\right]$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
tons = Output cooling capacity in tons (at AHRI standard rating conditions)
kBTU/h = Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
SEER = Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling in BTU, divided by the total electric energy input during the same period in watt-hours (used only for units with cooling capacity <65,000 BTU/h).
IEER = Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions (used only for units with cooling capacity ≥65,000 BTU/h)[633]
EER = Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTU/h divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
HSPF = Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours (used only for units with cooling capacity <65,000 BTU/h)
COP = Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions) (used only for units with cooling capacity ≥65,000 BTU/h)

[633] AHRI Standard 340/360 – 2015 & AHRI Standard 210/240 with Addenda 1 and 2 – 2012

$EFLH_{cooling}$ = Cooling equivalent full-load hours
$EFLH_{heating}$ = Heating equivalent full-load hours
CF = Coincidence factor
12 = (kBTU/h)/ton of air conditioning capacity
3.412 = Conversion factor, one watt/h equals 3.412 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
kBTU/h		From application
$SEER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
$SEER_{ee}$		From application
$HSPF_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
$HSPF_{ee}$		From application
$IEER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
$IEER_{ee}$		From application
$COP_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
COP_{ee}		From application
$EER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
EER_{ee}		From application
$EFLH_{heating}$		From application. If unknown, lookup based on building type and location from Appendix G.
$EFLH_{cooling}$		From application. If unknown, lookup based on building type and location from Appendix G.
CF	0.8	

The **SEER** is an estimate of the seasonal energy efficiency for an average US city for small units <65,000 BTU/h cooling output.

The **EER** is the rated full-load efficiency of the unit. It is used to estimate the efficiency of the unit under peak summer conditions.

The **IEER** is a weighted calculation of mechanical cooling efficiencies at full load and part load AHRI Standard Rating Conditions. Larger units are rated in IEER.

The **COP** is a ratio of the heating capacity in watts to the power input value in watts at any given set of AHRI Standard Rating Conditions.

The **HSPF** is the average space heating system efficiency during the space heating season in BTU/watt-hour for small units <65,000 BTU/h cooling output.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[634]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is defined as minimally code compliant equipment of type and cooling and heating capacities equivalent to the efficient case. The baseline efficiencies for unitary air conditioning and unitary and applied heat pump equipment are specified in the table below, as defined by International Energy Conservation Code and subsequently adopted by the Energy Conservation Construction Code of New York State[635] (ECCCNYS), and the New York City Energy Conservation Code[636] (NYCECC). EER requirements are not specified by state or city code for equipment with <65,000 BTU/h cooling capacity. For this equipment, baseline EER are established as follows[637]:

$$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$$

Resultant values from application of this equation to equipment with <65,000 BTU/h cooling capacity are tabulated in the baseline efficiencies table below.

Federal energy conservation standards[638] effective January 1, 2018 for small, large and very large package air conditioning and heating equipment are more stringent than NYS and NYC codes. These cases are denoted with footnotes in the table below.

Unitary Air Conditioners					
Equipment Type	**Size Category (Cooling Capacity)**	**Heating Section Type**	**Subcategory or Rating Condition**	**Baseline Efficiency (NYS)**	**Baseline Efficiency (NYC)**
Air conditioners (air cooled)	< 65,000 BTU/h (single phase)	All	Split System	11.2 EER 13.0 SEER	11.2 EER 13.0 SEER
			Single Package	11.8 EER 14.0 SEER	11.8 EER 14.0 SEER
Through-the-wall (air cooled)	≤ 30,000 BTU/h (single phase)	All	Split System	10.6 EER 12.0 SEER	10.6 EER 12.0 SEER
			Single Package	10.6 EER 12.0 SEER	10.6 EER 12.0 SEER
Small-duct high-velocity (air cooled)	< 65,000 BTU/h (single phase)	All	Split System	9.9 EER 11.0 SEER	9.9 EER 11.0 SEER

634 *No source specified – update pending availability and review of applicable references.*
635 ECCCNYS 2016, Table C403.2.3(1) & Table C403.2.3(2)
636 NYCECC 2016; Table C403.2.3(1) & Table C403.2.3(2)
637 DOE, Building America House Simulation Protocols, October 2010
638 10 CFR 431.97 (Table 3)

Unitary Air Conditioners					
Equipment Type	**Size Category (Cooling Capacity)**	**Heating Section Type**	**Subcategory or Rating Condition**	**Baseline Efficiency (NYS)**	**Baseline Efficiency (NYC)**
Air conditioners (air cooled)	≥ 65,000 BTU/h and < 135,000 BTU/h[639]	Electric Resistance (or None)	Split System and Single Package	11.2 EER 12.9 IEER	11.2 EER 12.9 IEER
		All Other	Split System and Single Package	11.0 EER 12.7 IEER	11.0 EER 12.7 IEER
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 12.4 IEER	11.0 EER 12.4 IEER
		All Other	Split System and Single Package	10.8 EER 12.2 IEER	10.8 EER 12.2 IEER
	≥ 240,000 BTU/h and < 760,000 BTU/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 11.6 IEER	10.0 EER 11.6 IEER
		All Other	Split System and Single Package	9.8 EER 11.4 IEER	9.8 EER 11.4 IEER
	≥ 760,000 BTU/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 11.2 IEER	9.7 EER 11.2 IEER
		All Other	Split System and Single Package	9.5 EER 11.0 IEER	9.5 EER 11.0 IEER

[639] For equipment with ≥65,000 BTU/h and <135,000 BTU/h cooling capacity, IEER values are taken from 10 CFR 431.97 (Table 3)

Unitary and Applied Heat Pumps					
Equipment Type	**Size Category (Cooling Capacity)**	**Heating Section Type**	**Subcategory or Rating Condition**	**Baseline Efficiency NYS**	**Baseline Efficiency NYC**
Cooling					
Air cooled (cooling mode)	< 65,000 BTU/h (single phase)	All	Split System	11.8 EER 14.0 SEER	11.8 EER 14.0 SEER
			Single Package	11.8 EER 14.0 SEER	11.8 EER 14.0 SEER
Through-the-wall (air cooled)	≥ 30,000 BTU/h (single phase)	All	Split System	10.6 EER 12.0 SEER	10.6 EER 12.0 SEER
			Single Package	10.6 EER 12.0 SEER	10.6 EER 12.0 SEER
Single-duct high-velocity (air cooled)	< 65,000 BTU/h (single phase)	All	Split System	9.9 EER 11.0 SEER	9.9 EER 11.0 SEER
Air cooled (cooling mode)	≥ 65,000 BTU/h and < 135,000 BTU/h[640]	Electric Resistance (or None)	Split System and Single Package	11.0 EER 12.2 IEER	11.0 EER 12.2 IEER
		All other	Split System and Single Package	10.8 EER 12.0 IEER	10.8 EER 12.0 IEER
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 11.6 IEER	10.6 EER 11.6 IEER
		All other	Split System and Single Package	10.4 EER 11.4 IEER	10.4 EER 11.4 IEER
	≥ 240,000 BTU/h[641]	Electric Resistance (or None)	Split System and Single Package	9.5 EER 10.6 IEER	9.5 EER 10.6 IEER
		All other	Split System and Single Package	9.3 EER 10.4 IEER	9.3 EER 10.4 IEER

[640] For equipment with ≥65,000 BTU/h and <135,000 BTU/h cooling capacity, IEER values are taken from 10 CFR 431.97 (Table 3)

[641] For equipment with ≥240,000 BTU/h cooling capacity, IEER values are taken from 10 CFR 431.97 (Table 3)

Unitary and Applied Heat Pumps					
Equipment Type	**Size Category (Cooling Capacity)**	**Heating Section Type**	**Subcategory or Rating Condition**	**Baseline Efficiency NYS**	**Baseline Efficiency NYC**
Heating					
Air cooled (heating mode)	< 65,000 BTU/h (single phase)	—	Split System	8.2 HSPF	8.2 HSPF
		—	Single Package	8.0 HSPF	8.0 HSPF
Through-the-wall (air cooled, heating mode)	≥ 30,000 BTU/h (single phase)	—	Split System	7.4 HSPF	7.4 HSPF
		—	Single Package	7.4 HSPF	7.4 HSPF
Small-duct high velocity (air cooled, heating mode)	< 65,000 BTU/h (single phase)	—	Split System	6.8 HSPF	6.8 HSPF
Air cooled (heating mode)	≥ 65,000 BTU/h and < 135,000 BTU/h	—	47ºF db/43ºF wb Outdoor Air	3.3 COP	3.3 COP
			17ºF db/15ºF wb Outdoor Air	2.25 COP	2.25 COP
	≥ 135,000 BTU/h	—	47ºF db/43ºF wb Outdoor Air	3.2 COP	3.2 COP
			17ºF db/15ºF wb Outdoor Air	2.05 COP	2.05 COP

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a high efficiency unitary air conditioning or unitary/applied heat pump system as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

Equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type and location can be found in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYSERDA, Mid- and High-Rise Multifamily Buildings
   Available from: https://www.nyserda.ny.gov/All-Programs/Programs/Low-Rise-Residential/Mid-and-High-Rise-Multifamily-Buildings
2. IBC 2015: Chapter 2 Definitions
   Available from: https://codes.iccsafe.org/content/IBC2015NY1/chapter-2-definitions
3. AHRI Standard 340/360, 2015 Standard for Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
   Available from:
   http://ahrinet.org/App_Content/ahri/files/STANDARDS/AHRI/AHRI_Standard_340-360_2015.pdf
4. AHRI Standard 210/240 with Addenda 1 and 2, 2008 Standard for Performance Rating of Unitary Air-Conditioning & Air Source Heat Pump Equipment, December 2012
   Available from:
   http://www.ahrinet.org/App_Content/ahri/files/standards%20pdfs/ANSI%20standards%20pdfs/ANSI.AHRI%20Standard%20210.240%20with%20Addenda%201%20and%202.pdf
5. C&I Unitary HVAC Load Shape Project Final Report, KEMA, August 2, 2011, Table 0-6 & Table 0-7
   Available from:
   http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2.pdf
6. ECCCNYS 2016, per IECC 2015; Table C403.2.3(1): Minimum Efficiency Requirements: Electrically Operated Unitary Air Conditioners and Condensing Units & Table C403.2.3(2): Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps
   Available from: https://codes.iccsafe.org/public/document/code/444/7965605
7. NYCECC 2016; Table C403.2.3(1): Minimum Efficiency Requirements: Electrically Operated Unitary Air Conditioners and Condensing Units & Table C403.2.3(2): Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
8. Building America House Simulation Protocols, Robert Hendron and Cheryn Engebrecht, National Renewable Energy Laboratory, October 2010
   Available from: https://www.nrel.gov/docs/fy11osti/49246.pdf

9. 10 CFR 431.97: Energy Efficiency Standards and Their Compliance Dates, Table 3: Updates to the Minimum Cooling Efficiency Standards for Air Conditioning and Heating Equipment
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=69945fdbe7327d148adc5e11b79bda36&node=se10.3.431_197&rgn=div8

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Record of Revision Number	Issue Date
1	10/15/2010
1-17-5	12/31/2016
12-17-2	12/31/2017
12-18-5	12/28/2018

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BLOWER FAN – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR FOR HVAC DISTRIBUTION

Measure Description

This measure covers the replacement of a HVAC circulation (blower) fan motor with an electronically commutated motor (EC motor) in a commercial building. The baseline condition for this measure is assumed to be a single-speed, permanent-split capacitor (PSC) motor. EC motors provide increased efficiency over PSC motors by controlling speed and torque, providing both efficiency and reliability.

This measure addresses the specific application of EC motors rated to one horsepower (HP) or less in a replacement scenario of a direct-drive circulation fan motor in an HVAC air distribution system. This measure is not applicable to exhaust fan motors.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

$$\Delta kWh_{cooling} = units \times \frac{(W_{baseline} \times ESF_{cooling})}{1{,}000} \times LF \times hrs \times (1 + HVAC_c)$$

$$\Delta kWh_{heating} = units \times \frac{(W_{baseline} \times ESF_{heating})}{1{,}000} \times LF \times hrs \times (1 - HVAC_c)$$

Peak Coincident Demand Savings

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

Annual Gas Savings

$$\Delta therms = units \times \frac{(W_{baseline} \times ESF_{heating})}{1{,}000} \times LF \times hrs \times HVAC_g$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$\Delta kWh_{cooling}$	= Annual electric energy savings during the cooling season
$\Delta kWh_{heating}$	= Annual electric energy savings during the heating season
$W_{baseline}$	= Baseline PSC motor wattage
ESF	= Energy savings factor
LF	= Motor load factor

hrs = Operating hours
$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor at utility summer peak hour
$HVAC_g$ = HVAC interaction factor for annual natural gas consumption
CF = Coincidence factor
1,000 = Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Sources

Variable	Value	Notes
$W_{baseline}$		From application.
$ESF_{heating}$	0.23	US Department of Energy. [642]
$ESF_{cooling}$	0.38	US Department of Energy. [643]
LF	0.9	US Department of Energy. [644]
hrs		From application, if unknown, see operating hours section below.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$		HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_g$		HVAC interaction factor for annual natural gas consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[645]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard efficiency, single-speed PSC motor in a direct-drive HVAC circulation (blower) fan application. Baseline wattage shall be derived from the nameplate rating of the existing motor.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an EC motor as described in the Measure Description section above in a direct-drive HVAC circulation (blower) fan application.

[642] US DOE, Evaluation of Retrofit Variable-Speed Furnace Fan Motors, January 2014, Section 4: Discussion, pg 23
[643] Ibid
[644] *No source specified – assumed value to reflect that motors do not typically run at 100% of rated power.*
[645] *No source specified – update pending availability and review of applicable references.*

Operating Hours

Operating hours shall be taken from application. If the operating hours are unknown and the circulation fan operates on the same schedule as the HVAC system, look up operating hours from Appendix G. If the operating hours are unknown and the circulation fan operates on the same schedule as the facility, look up hours by building type from the table below.

Facility Type	Hours (hrs/yr)	Facility Type	Hours (hrs/yr)
Auto Related[a]	2,810	Manufacturing Facility	2,857
Automotive / Transportation Service or Repair Facility (24/7)	8,760	Medical Offices	3,748
Bakery	2,854	Motion Picture Theatre	1,954
Banks	3,748	Multi-Family (Common Areas)	7,665
Church	1,955	Museum	3,748
College– Cafeteria[b]	2,713	Nursing Homes	5,840
College – Classes	2,586	Office (General Office Types)[b]	3,013
College - Dormitory	3,066	Parking Garages	4,368
Commercial Condos[c]	3,100	Parking Garages (24/7)	7,717
Convenience Stores	6,376	Parking Lots	4,100
Convention Center	1,954	Penitentiary	5,477
Court House	3,748	Performing Arts Theatre	2,586
Dining: Bar Lounge/Leisure	4,182	Police / Fire Stations (24 Hr)	7,665
Dining: Cafeteria / Fast Food	6,456	Post Office	3,748
Dining: Family	4,182	Pump Stations	1,949
Entertainment	1,952	Refrigerated Warehouse	2,602
Exercise Center	5,836	Religious Building	1,955
Fast Food Restaurants	6,376	Restaurants	4,182
Fire Station (Unmanned)	1,953	Retail	3,463
Food Stores	4,055	School / University	2,187
Gymnasium	2,586	Schools (Jr./Sr. High)	2,187
Hospitals	7,674	Schools (Preschool/Elementary)	2,187
Hospitals / Health Care	7,666	Schools (Technical/Vocational)	2,187
Industrial - 1 Shift	2,857	Small Services	3,750
Industrial - 2 Shift	4,730	Sports Arena	1,954
Industrial - 3 Shift	6,631	Town Hall	3,748
Laundromats	4,056	Transportation	6,456
Library	3,748	Warehouse (Not Refrigerated)	2,602
Light Manufacturers[b]	2,613	Waste Water Treatment Plant	6,631
Lodging (Hotels/Motels)	3,064	Workshop	3,750
Mall Concourse	4,833		

[a] New car showrooms and Big Box retail stores with evening and/or weekend hours should use the Facility Type "Retail" for lighting operating hours.
[b] Lighting operating hours data from the 2008 California DEER Update study
[c] Lighting operating hours data for offices used

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

HVAC circulation fan EC motors generate less heat during operation, resulting in decreased cooling loads and increased heating loads. These 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

HVAC circulation fan EC motors generate less heat during operation, resulting in decreased cooling loads and increased heating loads. These 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.

Improved fan impeller design in the efficient case may contribute to additional efficiency gains; these impacts are not considered in the prescribed methodology at this time.

References

1. US DOE, Evaluation of Retrofit Variable-Speed Furnace Fan Motors, R. Aldrich and J. Williamson, Consortium for Advanced Residential Buildings, January 2014
   Available from:
   http://digital.library.unt.edu/ark:/67531/metadc864348/m2/1/high_res_d/1122310.pdf
2. NIDEC Motor Corporation, Residential and Commercial HVACR Standard Motor Catalog, 2015
   Available from: http://acim.nidec.com/motors/usmotors/-/media/usmotors/documents/catalogs/hvacr/hvacr400.ashx?la=en

Record of Revision

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1-16-14	12/31/2015
6-18-13	6/26/2018

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CHILLER – AIR AND WATER COOLED

Measure Description

This measure applies to constant and variable speed electric air-cooled and water-cooled chillers in commercial buildings with built-up HVAC systems.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times (IPLV_{baseline} - IPLV_{ee}) \times EFLH_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times (FL_{baseline} - FL_{ee}) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
IPLV	= Integrated part-load value (in kW/Ton)
FL	= Full-load chiller efficiency under peak conditions
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
$FL_{baseline}$		Full-load efficiency of baseline chiller under peak conditions, lookup based on chiller type and size from Baseline Efficiencies tables below. Use Path A values for constant speed chillers and Path B values for variable speed chillers (based on proposed case).
FL_{ee}		Full-load efficiency of energy efficiency chiller, from application.

Variable	Value	Notes
$IPLV_{baseline}$		Integrated part-load value (kW/ton) of baseline chiller, lookup based on chiller type and size from Baseline Efficiencies tables below. Use Path A values for constant speed chillers and Path B values for variable speed chillers (based on proposed case).
$IPLV_{ee}$		Integrated part-load value (kW/ton) for energy efficient measure, from application.
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup by city, building type and HVAC type from Appendix G.
CF	0.8	

The rated full-load kW/ton (***FL***) at AHRI rating conditions is used to define the efficiency under peak conditions. The ***IPLV*** as defined by AHRI is used to define the annual average efficiency. Note, chiller full-load efficiency or IPLV may also be expressed as coefficient of performance (COP). To convert chiller efficiency from COP to kW/ton, use the following equation:
kW/ton = 3.517 / COP.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8. [646]

Baseline Efficiencies from which Savings are Calculated

The baseline full load and IPLV kW/Ton values listed in the tables below, per the 2016 Energy Conservation Construction Code of New York State [647] and 2016 New York City Energy Conservation Code[648], shall be used. Path A values shall be used for proposed constant speed chillers and Path B values for proposed variable speed chillers.

[646] *No source specified – update pending availability and review of applicable references.*
[647] ECCCNYS 2016, Table C403.2.3(7)
[648] NYCECC 2016; Table C403.2.3(7)

Path A – Constant Speed Chillers

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)	NYCECC Maximum Full Load (kW/Ton)	NYCECC Maximum IPLV (kW/Ton)
Air-Cooled Chillers	< 150 Tons	1.188	0.876	1.188	0.876
	≥ 150 Tons	1.188	0.857	1.188	0.857
Water-Cooled, Positive Displacement	< 75 Tons	0.750	0.600	0.750	0.600
	≥ 75 Tons and < 150 Tons	0.720	0.560	0.720	0.560
	≥ 150 Tons and < 300 Tons	0.660	0.540	0.660	0.540
	≥ 300 Tons and < 600 Tons	0.610	0.520	0.610	0.520
	≥ 600 Tons	0.560	0.500	0.560	0.500
Water Cooled, Centrifugal	< 150 Tons	0.610	0.550	0.610	0.550
	≥ 150 Tons and < 300 Tons	0.610	0.550	0.610	0.550
	≥ 300 Tons and < 400 Tons	0.560	0.520	0.560	0.520
	≥ 400 Tons and < 600 Tons	0.560	0.500	0.560	0.500
	≥ 600 Tons	0.560	0.500	0.560	0.500

Path B – Variable Speed Chillers

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)	NYCECC Maximum Full Load (kW/Ton)	NYCECC Maximum IPLV (kW/Ton)
Air-Cooled Chillers	< 150 Tons	1.237	0.759	1.237	0.759
	≥ 150 Tons	1.237	0.745	1.237	0.745
Water-Cooled, Positive Displacement	< 75 Tons	0.780	0.500	0.780	0.500
	≥ 75 Tons and < 150 Tons	0.750	0.490	0.750	0.490
	≥ 150 Tons and < 300 Tons	0.680	0.440	0.680	0.440
	≥ 300 Tons and < 600 Tons	0.625	0.410	0.625	0.410
	≥ 600 Tons	0.585	0.380	0.585	0.380

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)	NYCECC Maximum Full Load (kW/Ton)	NYCECC Maximum IPLV (kW/Ton)
Water Cooled, Centrifugal	< 150 Tons	0.695	0.440	0.695	0.440
	≥ 150 Tons and < 300 Tons	0.635	0.400	0.635	0.400
	≥ 300 Tons and < 400 Tons	0.595	0.390	0.595	0.390
	≥ 400 Tons and < 600 Tons	0.585	0.380	0.585	0.380
	≥ 600 Tons	0.585	0.380	0.585	0.380

Compliance Efficiency from which Incentives are Calculated

Compliance efficiency requirements shall be dictated by program eligibility criteria.

Operating Hours

Cooling equivalent full-load hours (EFLH) were calculated from a DOE-2.2 simulation of prototypical large office building. The prototype building characteristics are described in Appendix A. The $EFLH_{cooling}$ for built-up HVAC systems in commercial buildings by climate zone and building type are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ECCCNYS 2016, per IECC 2015; Table C403.2.3(7): Water Chilling Packages – Efficiency Requirements
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016; Table C403.2.3(7): Water Chilling Packages – Efficiency Requirements
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016

3. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: HVAC-Chlr. Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

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1	10/15/2010
9-17-3	9/30/2017

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CHILLER - COOLING TOWER

Measure Description

This measure covers the installation of close approach cooling towers applied to water-cooled chillers used for space cooling. Consumption and peak coincident demand savings are achieved through the installation of an over-sized cooling tower designed to provide an approach of ≤ 6°F at standard rating conditions. This measure addresses approach temperature only, which is defined as the difference between the cold water temperature (cooling tower outlet) and ambient wet bulb temperature. Changes in condenser water set point control strategies are not included.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons \times (\Delta kWh/ton)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons \times (\Delta kW/ton) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
tons = Size of cooling system (in tons) being retrofitted with a close approach tower
(ΔkWh/ton) = Annual electric energy savings per ton of cooling
(ΔkW/ton) = Electric demand savings per ton of cooling
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
(ΔkWh/ton)		Annual electric energy savings per ton of cooling system retrofitted with close approach tower. Look up in Appendix J based on building type, HVAC type and location.
(ΔkW/ton)		Electric demand savings per ton of cooling system retrofitted with close approach tower. Look up in Appendix J based on building type, HVAC type and location
CF	0.8	

Unit energy savings were calculated from a DOE-2.2 simulation of commercial buildings with built-up HVAC systems. The prototype building characteristics are described in Appendix A. The unit energy savings by building type across different cities in NY are shown in Appendix J.

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[649]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a standard cooling tower with a 10°F approach temperature under standard rating conditions.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a close approach cooling tower with a 6°F approach temperature under standard rating conditions.

Operating Hours

The HVAC system operating hours vary by building type. Operating hour assumptions for the prototypical building models are described in Appendix A.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

N/A

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1	10/15/2010
12-17-12	12/31/2017

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

Chiller System Tune-Ups

Measure Description

Chiller system tune-ups are conducted to ensure equipment is operating at optimal performance and are performed as preventative maintenance, extending the life of the equipment. The tune-ups improve the efficiency and performance of the chillers and are useful system checks to ensure maintenance is performed to keep the equipment operating. Testing and maintenance conducted as part of a typical chiller tune-up include: checking and cleaning evaporator and condenser coils/tubes, checking and replacing filters, belts, and contactors, checking cooling towers for buildup/scale, checking control operation and setpoints, checking crankcase heater operation and checking economizer function.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{tons}{unit} \times (IPLV_{baseline} \times ESF) \times EFLH_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{tons}{unit} \times \left(kW/ton_{baseline} \times DSF\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of chillers addressed under the program
tons/unit = Tons of air conditioning per chiller, based on nameplate data
$EFLH_{cooling}$ = Equivalent full-load cooling hours
CF = Coincidence factor
$IPLV_{baseline}$ = Integrated part-load value (kW/ton)
$kW/ton_{baseline}$ = Full load chiller efficiency under peak conditions
ESF = Energy savings factor
DSF = Demand savings factor

Summary of Variables and Data Sources

Variable	Value	Notes
$IPLV_{baseline}$		Based on nameplate data, if available. Otherwise, use values from Baseline Efficiency table below.

Variable	Value	Notes
$kW/ton_{baseline}$		Based on nameplate data, if available. Otherwise, use values from Baseline Efficiency table below.
ESF	0.05	Energy Savings Factor (efficiency recovered from tune-up) [650]
DSF	0.025	Demand Savings Factor (efficiency recovered from tune-up) [651]
$EFLH_{cooling}$		Cooling equivalent full-load hours by building type, Appendix G.
CF	0.8	Coincidence Factor

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8. [652]

Baseline Efficiencies from which Savings are Calculated

The baseline full load and IPLV kW/Ton values shall be based on actual manufacturers' catalog for the existing chiller, where available. If this information is unavailable, the efficiencies listed in the table below, per the 2016 Energy Conservation Construction Code of New York State[653] and 2016 New York City Energy Conservation Code[654], shall be used.

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)	NYCECC Maximum Full Load (kW/Ton)	NYCECC Maximum IPLV (kW/Ton)
Air-Cooled Chillers	< 150 Tons	1.188	0.876	1.188	0.876
	≥ 150 Tons	1.188	0.857	1.188	0.857
Water-Cooled, Positive Displacement	< 75 Tons	0.750	0.600	0.750	0.600
	≥ 75 Tons and < 150 Tons	0.720	0.560	0.720	0.560
	≥ 150 Tons and < 300 Tons	0.660	0.540	0.660	0.540
	≥ 300 Tons and < 600 Tons	0.610	0.520	0.610	0.520
	≥ 600 Tons	0.560	0.500	0.560	0.500

[650] US DOE: Hospitals Benefit by Improving Inefficient Chiller Systems, August 2011
[651] Conservative estimate based on engineering judgement, estimated at half of the established 5% energy savings factor
[652] *No source specified – update pending availability and review of applicable references.*
[653] ECCCNYS 2016, Table C403.2.3(7)
[654] NYCECC 2016; Table C403.2.3(7)

Equipment Type	Size Category	ECCCNYS Maximum Full Load (kW/Ton)	ECCCNYS Maximum IPLV (kW/Ton)	NYCECC Maximum Full Load (kW/Ton)	NYCECC Maximum IPLV (kW/Ton)
Water Cooled, Centrifugal	< 150 Tons	0.610	0.550	0.610	0.550
	≥ 150 Tons and < 300 Tons	0.610	0.550	0.610	0.550
	≥ 300 Tons and < 400 Tons	0.560	0.520	0.560	0.520
	≥ 400 Tons and < 600 Tons	0.560	0.500	0.560	0.500
	≥ 600 Tons	0.560	0.500	0.560	0.500

Compliance Efficiency from which Incentives are Calculated

Compliance for incentive eligibility will be dictated by minimum tune-up standards of the applicable program.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. United States Department of Energy, Building Technologies Program: Hospitas Benefit by Improving Inefficient Chiller Systems, August 2011. The paper found that dirty coils can cause a 7% reduction in cooling capacity. Therefore, coil cleaning, the primary savings mechanism associated with this tune-up measure, is conservatively assumed to save 5% of total consumption. Demand savings are conservatively assumed to be half of this, or 2.5%.
2. ECCCNYS 2016, per IECC 2015; Table C403.2.3(7): Water Chilling Packages – Efficiency Requirements
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency

3. NYCECC 2016; Table C403.2.3(7): Water Chilling Packages – Efficiency Requirements Available from: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
4. Wisconsin Public Service Commission: Equipment Useful Life Database, 2013 Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

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6-17-12	6/30/2017

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DUCT SEALING AND INSULATION

Measure Description

This measure covers the installation of sealing and insulation of the space heating and air conditioning distribution system (including air handlers, filter boxes and building cavities used as ducts before code change) in the unconditioned spaces of commercial facilities. Duct sealing and insulation reduces air and thermal leakage into unconditioned and outdoor spaces, improving system efficiency. Sealing and insulation installed under this measure shall meet or exceed all applicable construction code requirements. This measure is only applicable in existing buildings. This excludes gut rehab projects, which shall be considered new construction. Only ductwork located outside of the thermal envelope is eligible for energy savings.

This measure is to be implemented with a visual inspection and an outdoor duct leakage test on the distribution system pre- and post-implementation.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For AC and HP Units with Capacity <65,000 BTU/h

$$\Delta kWh = \left[tons \times \frac{12}{SEER} \times EFLH_{cooling} \times \left(1 - \frac{Eff_{dist,cooling,baseline}}{Eff_{dist,cooling,ee}}\right) \times \left(1 - TRF_{cooling}\right)\right] + \left[kBTU/h_{out} \times \frac{1}{HSPF} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times \left(1 - TRF_{heating}\right)\right]$$

For AC and HP Units with Capacity ≥65,000 BTU/h

$$\Delta kWh = \left[tons \times \frac{12}{IEER} \times EFLH_{cooling} \times \left(1 - \frac{Eff_{dist,cooling,baseline}}{Eff_{dist,cooling,ee}}\right) \times \left(1 - TRF_{cooling}\right)\right] + \left[\frac{kBTU/h_{out}}{3.412} \times \frac{1}{COP} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times \left(1 - TRF_{heating}\right)\right]$$

For Electric Furnaces

$$\Delta kWh = kW_{in} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times \left(1 - TRF_{heating}\right)$$

Peak Coincident Demand savings

For AC and HP Units

$$\Delta kW = tons \times \frac{12}{EER} \times \left(1 - \frac{Eff_{dist,cooling,baseline}}{Eff_{dist,cooling,ee}}\right) \times \left(1 - TRF_{cooling}\right) \times CF$$

Annual Gas Energy Savings

For Gas Furnaces with Capacity < 225,000 BTU/h

$$\Delta therms = \frac{kBTU/h_{in}}{100} \times EFLH_{heating} \times \left(1 - \frac{Eff_{dist,heating,baseline}}{Eff_{dist,heating,ee}}\right) \times \left(1 - TRF_{heating}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
tons	= Output cooling capacity in tons (at AHRI standard rating conditions)
$kBTU/h_{out}$	= Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
kW_{in}	= Input heating capacity in kW
$kBTU/h_{in}$	= Input heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
TRF	= Thermal Regain Factor
SEER	= Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling in BTU, divided by the total electric energy input during the same period in watt-hours
IEER	= Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions
EER	= Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTU/h divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
HSPF	= Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
EFLH	= Equivalent full-load hours
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
Eff_{dist}	= Distribution system efficiency
CF	= Coincidence factor
12	= (kBTU/h)/ton of air conditioning capacity
3.412	= Conversion factor, one watt-hour equals 3.412 BTU
100	= Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application.
$kBTU/h_{out}$		From application.
kW_{in}		From application.

Variable	Value	Notes
$kBTU/h_{in}$		From application.
$TRF_{cooling}$		See table in the Thermal Regain Factor section below.
$TRF_{heating}$		See table in the Thermal Regain Factor section below.
IEER		Actual equipment nameplate IEER.
EER		Actual equipment nameplate EER.
HSPF		Actual equipment nameplate HSPF.
COP		Actual equipment nameplate COP.
$EFLH_{heating}$		From application. If unknown, look up based on building type, vintage and location from Appendix G.
$EFLH_{cooling}$		From application. If unknown, look up based on building type, vintage and location from Appendix G.
$Eff_{dist,cooling,baseline}$		Look up in Appendix H for uninsulated duct system based on building type, location and duct leakage in cooling mode.
$Eff_{dist,heating,baseline}$		Look up in Appendix H for uninsulated duct system based on building type, location and duct leakage in heating mode.
$Eff_{dist,cooling,ee}$		Look up in Appendix H for R-6 insulated duct system based on building type, location and duct leakage in cooling mode.
$Eff_{dist,heating,ee}$		Look up in Appendix H for R-6 insulated duct system based on building type, location and duct leakage in heating mode.
CF	0.8	

Thermal Regain Factor[655]

Some energy loss from poorly sealed and insulated ducts can be regained through conduction back into conditioned spaces. The table below lists default thermal regain factors depending on the location of the ductwork.

Duct Location	$TRF_{cooling}$	$TRF_{heating}$
Attic	0.10	0.10
Garage	0.10	0.10
Crawl space, unvented, uninsulated	0.60	0.60
Crawl Space, Unvented, Insulated Building Floor and Crawl Space walls	0.60	0.30
Crawl Space, Unvented, Insulated Floor Only	0.30	0.30
Crawl Space, Vented, Uninsulated	0.60	0.55
Crawl Space, Insulated Building Floor and Crawl Space Walls	0.63	0.60
Crawl Space, Vented, Insulated Floor Only	0.30	0.30
Basement, Uninsulated	0.50	0.50
Basement, Insulated Walls	0.60	0.60
Under-slab	0.20	0.20

655 Home Energy Saver & Score: Engineering Documentation, Thermal Distribution Efficiency

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8. [656]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a ducted HVAC system with insufficient sealing and insulation that has undergone duct leakage testing. Look up baseline uninsulated distribution system efficiency from Appendix H based on building type, location and duct total leakage.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a sealed and insulated duct system in a commercial building that has undergone post-implementation duct leakage testing. A duct leakage test is turned on to pressurize the duct system to 25 Pascals (the standardized pressure differential used as a baseline for a commercial duct leakage test). The results are reported as "cfm @ 25 Pascals (0.1 inches w.g.)". The post-installation case must comply with all provisions of enforced codes and standards including, but not limited to ECCCNYS, NYCECC, and IMC 2015[657]. Supply and return air ducts and plenums located in unconditioned spaces shall be insulated with a minimum of R-6 insulation. Where located outside the building, ducts and plenums shall be insulated with a minimum of R-8 insulation in Climate Zone 4 and with a minimum of R-12 in Climate Zones 5 and 6.[658]

Look up compliance distribution system efficiency from Appendix H based on building type, location and duct total leakage from duct leakage test. Models for HVAC distribution efficiency with R-8 and R-12 insulation are currently under development; values associated with R-6 shall be used until data is available.

Operating Hours

Cooling and heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for residential buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

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656 *No source specified – update pending availability and review of applicable references.*
657 IMC 2015, C6 Duct Systems
658 ECCCNYS 2016 & NYCECC 2016, C403.2.9

References

1. Home Energy Saver & Score: Engineering Documentation, Thermal Distribution Efficiency Available from: http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/heating-and-cooling-calculation/thermal-distribution-efficiency/thermal-distribution-efficiency
2. IMC 20125; C6 Duct Systems
Available from: https://codes.iccsafe.org/public/document/IMC2015NY-1/chapter-6-duct-systems
3. ECCCNYS 2016, per IECC 2015; C403.2.9: Duct and Plenum Insulation and Sealing
Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
4. NYCECC 2016; C403.2.9: Duct and Plenum Insulation and Sealing
Available from:
https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
9-18-13	9/28/2018

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ECONOMIZER – AIR SIDE, WITH DUAL ENTHALPY CONTROL

Measure Description

This measure covers the installation of dual enthalpy control air-side economizers integrated into a central air handling system on packaged rooftop units. Air-side economizers reduce mechanical cooling requirements by supplying outside air to the space when the outside air meets conditions deemed suitable for cooling. Dual enthalpy control, often called differential enthalpy control, augments this functionality by measuring sensible and latent heat of both the outside air and return air, using dampers to supply the conditioning section of the air handler with the lowest enthalpy air supply. This measure applies to retrofit scenarios for small commercial applications only. This measure also only applies in cases where economizers are not required by state, federal, or local code.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
(ΔkWh/ton)	= Annual electric energy savings per ton of cooling

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application
(ΔkWh/ton)		Lookup based on building type and location in the Air Side Economizer table in Appendix J.

Unit energy savings were calculated from a DOE-2.2 simulation of a series of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy savings by building type and city are shown in Appendix J.

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a packaged rooftop unit with no economizer installed.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a packaged rooftop unit with dual enthalpy economizer installed and commissioned to ensure proper operation.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

N/A

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
3-18-3	3/29/2018

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Furnace and Boiler

Measure Description

This measure covers high-efficiency gas-fired furnaces, boilers and unit heaters used for space heating installed in all buildings except low-rise residential (single and multifamily) applications. The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local energy conservation code.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{unit} \times \left(\frac{Eff_{ee}}{Eff_{baseline}} - 1\right) \times \frac{EFLH_{heating}}{100}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$kBTU/h_{in}$	= Fuel input rating of the efficient equipment
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
Eff	= Energy efficiency (0-100%)
$EFLH_{heating}$	= Heating equivalent full-load hours
100	= Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$(kBTU/h)_{in}/unit$		Nameplate input rating of the efficient unit, from application.
$Eff_{baseline}$		Baseline established by applicable energy conservation code, climatic zone, equipment type and size, fuel source, and system configuration. See Baseline Efficiency section below.
Eff_{ee}		From application.
$EFLH_{heating}$		From application. If unknown, lookup based on building type and location from Appendix G.

Efficiency is expressed as the ratio of the fuel input relative to the output heating capacity. The efficiency of furnaces, boilers and unit heaters is customarily evaluated on the basis of one or more of three standards, namely Thermal Efficiency (E_t), Combustion Efficiency, (E_c) and Annual Fuel Utilization Efficiency (AFUE).

Presently, the AFUE value is only applicable to smaller units (<300 kBTU/h for boilers and <225 kBTU/h for furnaces). For larger units, use thermal and combustion efficiencies referenced on manufacturer’s nameplate data in accordance with nationally recognized standards and testing agencies.

Coincidence Factor (CF)

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

Baseline Efficiencies From Which Savings are Calculated

The baseline condition is a minimally code compliant system of type and capacity equivalent to the efficient condition. The baseline efficiency for commercial furnaces, boilers, and unit heaters ($\eta_{baseline}$) is defined by the Code of Federal Regulations (CFR) and subsequently adopted by the Energy Conservation Construction Code of New York State[659] and the New York City Energy Conservation Code[660] as shown below.

Equipment Type	Size Range	ECCCNYS Minimum Efficiency for Climate Zones 4, 5 and 6	NYCECC Minimum Efficiency for NYC Boroughs in Climate Zone 4
Warm Air Furnace, Gas Fired	< 225 kBTU/h	0.78 AFUE or 0.80 E_t	0.78 AFUE or 0.80 E_t
	≥ 225 kBTU/h	0.80 E_t	0.80 E_t
Warm Air Unit Heaters, Gas Fired	All Capacities	0.80 E_c	0.80 E_c
Boiler, Hot Water, Gas Fired	< 300 kBTU/h	0.80 AFUE	0.80 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.80 E_t	0.80 E_t
	> 2,500 kBTU/h	0.82 E_c	0.82 E_c
Boiler, Steam, Gas Fired, All Except Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.79 E_t	0.79 E_t
	> 2,500 kBTU/h	0.79 E_t	0.79 E_t
Boiler, Steam, Gas Fired, Natural Draft	< 300 kBTU/h	0.75 AFUE	0.75 AFUE
	≥ 300 kBTU/h and ≤ 2,500 kBTU/h	0.77 E_t	0.77 E_t
	> 2,500 kBTU/h	0.77 E_t	0.77 E_t

[659] ECCCNYS 2016, Table C403.2.3(4) and Table C403.2.3(5)
[660] NYCECC 2016; Table C403.2.3(4) and Table C403.2.3(5)

Compliance Efficiencies From Which Incentives are Calculated

The compliance condition is a gas-fired furnace, boiler or unit heater used for space heating as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

High efficiency furnaces may be packaged with high efficiency cooling equipment and/or electronically commutated blower motors, which may provide electricity savings. Draft fans, when present, will increase electricity consumption. These ancillary impacts are not included in the savings estimation approach detailed above.

References

1. ECCCNYS 2016, per IECC 2015; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers.
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016; Table C403.2.3(4): Warm-Air Furnaces And Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces And Unit Heaters, Minimum Efficiency Requirements & Table C403.2.3(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-15-7	6/1/2015
1-16-4	12/31/2015
12-17-13	12/31/2017

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BOILER TUNE-UP

Measure Description

This measure applies to gas-fired hot water and steam boilers used for process loads or space heating not covered under 40 CFR Part 63 Subpart 6J[661]. Tune-up will improve boiler efficiency by cleaning burners, combustion chamber and burner nozzles, adjusting air flow and reducing excessive stack temperatures, adjusting burner and gas input and checking venting, safety controls, and adequacy of combustion air intake. Combustion efficiency must be measured before and after tune-up using a flue gas analyzer.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{(kBTU/h)_{in}/unit}{100 \times LF} \times \left(1 - \frac{E_{c,baseline}}{E_{c,ee}}\right) \times EFLH_{heating}$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of boilers addressed under the program
$(kBTU/h)_{in}/unit$ = Fuel input rating per boiler, based on nameplate data
$EFLH_{heating}$ = Equivalent full-load heating hours
LF = Load Factor
100 = Conversion factor, (kBTU/Therm)
$E_{c,baseline}$ = Baseline combustion efficiency as determined via flue gas analysis
$E_{c,ee}$ = Post-implementation combustion efficiency as determined via flue gas analysis

Summary of Variables and Data Sources

Variable	Value	Notes
$(kBTU/h)_{in}/unit$		Nominal heating input capacity is the nameplate input rating of the unit in kBTU/h, from application.
LF	1.3	Assumes 30% boiler oversizing[662]
$E_{c,baseline}$		Efficiency as measured in pre-tune-up inspection

[661] 40 CFR 63 Subpart JJJJJJ: https://www.ecfr.gov/cgi-bin/text-idx?node=sp40.15.63.jjjjjj
[662] PA Consulting, KEMA, Focus on Energy Evaluation, Match 22, 2010

Variable	Value	Notes
$E_{c,ee}$		Post-tune-up efficiency as measured post-tune-up
$EFLH_{heating}$		For space heat; lookup based on building type and location, Appendix G. For process heat use hours of operation from application

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency is the combustion efficiency of the boiler measured during pre-tune-up inspection via flue gas analysis.

Compliance Efficiency from which Incentives are Calculated

The compliance efficiency is the combustion efficiency of the boiler measured after tune-up via flue gas analysis.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. PA Consulting, KEMA, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010. This factor implies that boilers are 30% oversized on average.
   Available from:
   https://focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf

2. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: BlrTuneup
Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

Record of Revision Number	**Issue Date**
6-17-13	6/30/2017

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AIR CONDITIONER AND HEAT PUMP – PACKAGED TERMINAL

Measure Description

This measure covers installation of high efficiency unitary air conditioners and unitary and applied heat pumps in commercial applications. The baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local energy conservation code.

Packaged Terminal Air Conditioner (PTAC)
A wall sleeve and a separate un-encased combination of heating and cooling assemblies specified by the manufacturer and intended for mounting through the wall. It includes refrigeration components, separable outdoor louvres, forced ventilation, and heating availability by purchaser's choice of, at least, hot water, steam, or electrical resistance heat.

Note: *Models designated as "cooling only" units need not include heating elements if the physical characteristics and arrangement of the refrigeration system are identical to those of models with heating availability.*[663]

Packaged Terminal Heat Pump (PTHP)
A separate un-encased refrigeration system installed in a cabinet having a function and configuration similar to that of a packaged terminal air-conditioner. It uses reverse cycle refrigeration as its prime heat source and should have other supplementary heat source(s) available to purchasers with the choice of, at least, hot water, steam, or electric resistance heat.[664,665]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\begin{array}{c}\left(\frac{kBTU/h_{cooling}}{unit} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times EFLH_{cooling}\right) \\ + \\ \left(\frac{kBTU/h_{heating}}{unit \times 3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right)\end{array}\right]$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left[\left(\frac{kBTU/h_{cooling}}{unit} \times \left(\frac{1}{EER_{baseline}} - \frac{1}{EER_{ee}}\right) \times CF\right)\right]$$

[663] AHRI Standard 310/380 – 2014
[664] Ibid.
[665] Replacement unit shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) in height and less than 42 inches (1067 mm) in width.

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$kBTU/h_{cooling}$	= Output cooling capacity in kBTU/h (at AHRI standard rating conditions)
$kBTU/h_{heating}$	= Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
EER	= Energy efficiency ratio, measurement of cooling capacity for a unit (in BTU/hour) / electrical energy used (watts) (at AHRI standard rating conditions)
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
$EFLH_{heating}$	= Heating equivalent full-load hours
3.412	= Conversion factor, one watt-hour equals 3.412 BTU
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTU/h_{cooling}$		From application
$kBTU/h_{heating}$		From application
$COP_{baseline}$		Calculate from Baseline Efficiencies table below based on equipment type, size category and capacity.
COP_{ee}		From application
$EER_{baseline}$		Calculate from Baseline Efficiencies table below based on equipment type, size category and capacity.
EER_{ee}		From application
$EFLH_{heating}$		From application. If unknown, lookup based on building type and location from Appendix G.
$EFLH_{cooling}$		From application. If unknown, lookup based on building type and location from Appendix G.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[666]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is defined as minimally code compliant equipment of type and cooling and

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

heating capacities equivalent to the efficient case. The baseline efficiencies are calculated based on rated equipment input capacity in BTU/h and are defined by International Energy Conservation Code[667] and subsequently adopted by the Energy Conservation Construction Code of New York State (ECCCNYS) and the New York City Energy Conservation Code[668] (NYCECC) as shown below. The formulas in the rightmost column shall be used to establish the baseline efficiency in the units specified (EER or COP).

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency ECCCNYS and NYCECC[669]
PTAC (Cooling Mode) Standard Size	All Capacities	95°F db Outdoor Air	EER = 14.0 - (0.300 × Cap/1,000)
PTAC (Cooling Mode) Replacements/ Nonstandard Size[670]	All Capacities	95°F db Outdoor Air	EER = 10.9 - (0.213 × Cap/1,000)
PTHP (Cooling Mode) Standard Size	All Capacities	95°F db Outdoor Air	EER = 14.0 - (0.300 × Cap/1,000)
PTHP (Cooling Mode) Replacements/ Nonstandard Size	All Capacities	95°F db Outdoor Air	EER = 10.8 - (0.213 × Cap/1,000)
PTHP (Heating Mode) Standard Size	All Capacities	—	NYS: COP = 3.2 – (0.026 × Cap/1,000) NYC: COP = 3.7 – (0.052 × Cap/1,000)
PTHP (Heating Mode) Replacements/ Nonstandard Size	All Capacities	—	COP = 2.9 - (0.026 × Cap/1,000)

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a high efficiency packaged terminal air conditioner or heat pump system as defined in the Measure Description section above meeting minimum performance requirements dictated by program eligibility criteria.

[667] ECCCNYS 2016, Table C403.2.3(3)
[668] NYCECC 2016, Table C403.2.3(3)
[669] "Cap" = The rated cooling capacity of the project in BTU/h. If the unit's capacity is less than 7,000 BTU/h, use 7,000 BTU/h in the calculation. If the unit's capacity is greater than 15,000 BTU/h, use 15,000 BTU/h in the calculations."
[670] Replacement/Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement/Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16 in. high or less than 42 in. wide and having a cross-sectional area less than 670 in.

Operating Hours

Equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type and location can be found in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. AHRI Standard 310/380 – 2014: Standard for Packaged Terminal Air-Conditioners and Heat Pumps
   Available from:
   http://www.ahrinet.org/App_Content/ahri/files/STANDARDS/AHRI/AHRI_Standard_310_380-2014_CSA_C744-14.pdf
2. C&I Unitary HVAC Load Shape Project Final Report, KEMA, August 2, 2011, Table 0-6
   Available from:
   http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2.pdf
3. ECCCNYS 2016, per IECC 2015; Table C403.2.3(3): Minimum Efficiency Requirements: Electrically Operated Unitary Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single Vertical Heat Pumps, Room Air Conditioners and Room Air Conditioner Heat Pumps
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
4. NYCECC 2016; Table C403.2.3(3): Minimum Efficiency Requirements: Electrically Operated Unitary Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single Vertical Heat Pumps, Room Air Conditioners and Room Air Conditioner Heat Pumps
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
1-17-6	12/31/2016
12-17-14	12/31/2017

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WATER SOURCE HEAT PUMPS

Measure Description

This measure covers the installation of high-efficiency Water Source Heat Pumps (WSHP), as defined below, in commercial applications including multifamily buildings with four or more stories[671] or with an occupied floor located more than 75 feet above the lowest level of fire department vehicle access[672]. In both replacement and new construction/major renovation projects, the baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local code. This measure is restricted to systems that serve as the primary space heating and cooling system for the facility.

Water Source Heat Pumps

Water Source Heat Pumps may consist of one or more factory-made assemblies that include indoor space conditioning and/or domestic water heating heat exchanger(s), compressor(s), and a liquid-side heat exchanger. When provided in more than one assembly, the separate assemblies are designed to be used together. Water Source Heat Pumps may provide space heating, space cooling, domestic water heating, or a combination of these functions and may also include the functions of liquid circulation, thermal storage, air circulation, air cleaning, dehumidifying or humidifying. There are two classes of Water Source Heat Pumps: Water-to-Air Heat Pumps and Water-to-Water Heat Pumps.

Water-to-Air Heat Pumps

Water-to-Air Heat Pumps provide space conditioning primarily by the use of an indoor air heat exchange coil. Water-to-Air models may also provide domestic water heating and hydronic space heating by using desuperheater and/or demand water heating functions.

Water-to-Water Heat Pumps

Water-to-Water Heat Pumps provide space conditioning and/or domestic water heating by the use of indoor refrigerant-to-water heat exchanger(s). Water-to-Water models may provide domestic water heating by using desuperheater and/or demand water heating functions.[673]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times EFLH_{cooling} + \frac{kBTUh/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right]$$

[671] NYSERDA, Mid- and High-Rise Multifamily Buildings
[672] IBC 2015; Chapter 2 Definitions: High-Rise Building
[673] AHRI, Geothermal and Water Source Heat Pumps (http://www.ahrinet.org/About-Us/Product-Sections/Geothermal-and-Water-Source-Heat-Pumps)

Peak Coincident Demand Savings

$$\Delta kW = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons	= Output cooling capacity in tons (at AHRI standard rating conditions)
kBTU/h	= Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
EER	= Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTU/hr divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
COP	= Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
$EFLH_{heating}$	= Heating equivalent full-load hours
CF	= Coincidence factor
12	= (kBTU/h)/ton of air conditioning capacity
3.412	= Conversion factor, one watt-h equals 3.412 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
kBTU/h		From application
$COP_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
COP_{ee}		From application
$EER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
EER_{ee}		From application
$EFLH_{heating}$		From application. If unknown, lookup based on building type and location from Appendix G.
$EFLH_{cooling}$		From application. If unknown, lookup based on building type and location from Appendix G.
CF	0.8	

The **EER** is the rated full-load efficiency of the unit. It is used to estimate the efficiency of the unit under peak summer conditions.

The **COP** is a ratio of the heating capacity in watts to the power input value in watts at any given set of AHRI Standard Rating Conditions.

Coincidence Factor (CF)

The prescribed value for the coincidence factor in the cooling mode is 0.8[674]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is defined as minimally code compliant equipment of type and cooling and heating capacities equivalent to the efficient case. The baseline efficiencies for electrically operated unitary and applied water source heat pump equipment are specified in the table below, as defined by International Energy Conservation Code and subsequently adopted by the Energy Conservation Construction Code of New York State[675] (ECCCNYS) and the New York City Energy Conservation Code[676] (NYCECC).

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency As of 1/1/2016	Test Procedure
Water to Air: Water Loop (cooling mode)	< 17,000 BTU/h	All	86°F entering water	12.2 EER	ISO 13256-1
	≥ 17,000 BTU/h and < 65,000 BTU/h	All	86°F entering water	13.0 EER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	All	86°F entering water	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 BTU/h	All	59°F entering water	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 BTU/h	All	77°F entering water	14.1 EER	ISO 13256-1
Water to Water: Water Loop (cooling mode)	< 135,000 BTU/h	All	86°F entering water	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 BTU/h	All	59°F entering water	16.3 EER	ISO 13256-2

[674] *No source specified – update pending availability and review of applicable references.*
[675] ECCCNYS 2016, Table C403.2.3(1) & Table C403.2.3(2)
[676] NYCECC 2016; Table C403.2.3(1) & Table C403.2.3(2)

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency As of 1/1/2016	Test Procedure
Brine to Water: Ground Loop (cooling mode)	< 135,000 BTU/h	All	77°F entering water	12.1 EER	ISO 13256-2
Water to Air: Water Loop (heating mode)	< 135,000 BTU/h	-	68°F entering water	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 BTU/h	-	50°F entering water	3.7 COP	ISO 13256-1
Brine to Air: Ground Loop (heating mode	< 135,000 BTU/h	-	32°F entering fluid	3.2 COP	ISO 13256-1
Water to Water: Water Loop (heating mode)	< 135,000 BTU/h	-	68°F entering water	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 BTU/h	-	50°F entering water	3.1 COP	ISO 13256-2
Brine to Water: Ground Loop (heating mode)	< 135,000 BTU/h	-	32°F entering fluid	2.5 COP	ISO 13256-2

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a high efficiency water source heat pump as defined in the Measure Description section above which meets CEE Tier 1[677] or ENERGY STAR® Tier 3[678] minimum requirements, provided in the table below for reference. Qualifying equipment must exceed state and local codes in cases where code is more stringent than CEE Tier 1 or ENERGY STAR®.

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency As of 1/1/2016	Test Procedure
Water to Air or Water to Water: Water Loop (cooling mode)	< 135,000 BTU/h	All	86° Entering Water	14 EER	ISO 13256-1

[677] 2018 CEE High Efficiency Commercial Air Conditioning and Heat Pumps Initiative, Appendix B, Unitary Heat Pump Specification, page 42 (accessed 11/27/2018). Specification for water source.
[678] ENERGY STAR® Program Requirements Product Specification for Geothermal Heat Pumps Eligibility Criteria Version 3.1, Rev. March 2012. The specification is for residential ground loop and ground water heat pumps but is applied here as a proxy for establishing minimum qualifying efficiency requirements.

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency As of 1/1/2016	Test Procedure
Water to Air: Ground Water (cooling mode)	< 135,000 BTU/h	All	59°F entering water	21.1 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 BTU/h	All	77°F entering water	17.1 EER	ISO 13256-1
Water to Water: Ground Water (cooling mode)	< 135,000 BTU/h	All	59°F entering water	20.1 EER	ISO 13256-2
Brine to Water: Ground Loop (cooling mode)	< 135,000 BTU/h	All	77°F entering water	16.1 EER	ISO 13256-2
Water to Air or Water to Water: Water Loop (heating mode)	< 135,000 BTU/h	-	68° Entering Water	4.6 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 BTU/h	-	50°F entering water	4.1 COP	ISO 13256-1
Brine to Air: Ground Loop (heating mode)	< 135,000 BTU/h	-	32°F entering water	3.6 COP	ISO 13256-1
Water to Water: Ground Water (heating mode)	< 135,000 BTU/h	-	50°F entering water	3.5 COP	ISO 13256-2
Brine to Water: Ground Loop (heating mode)	< 135,000 BTU/h	-	32°F entering water	3.1 COP	ISO 13256-2

Operating Hours

Equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type and location can be found in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYSERDA, Mid- and High-Rise Multifamily Buildings
   Available from: https://www.nyserda.ny.gov/All-Programs/Programs/Low-Rise-Residential/Mid-and-High-Rise-Multifamily-Buildings
2. IBC 2015: Chapter 2 Definitions
   Available from: https://codes.iccsafe.org/content/IBC2015NY1/chapter-2-definitions
3. AHRI Geothermal and Water-Source Heat Pumps, Section Scope
   Available from: http://www.ahrinet.org/About-Us/Product-Sections/Geothermal-and-Water-Source-Heat-Pumps
4. AHRI Standard 210/240, 2017 Standard for Performance Rating of Unitary Air-Conditioning & Air Source Heat Pump Equipment
   Available from:
   http://www.ahrinet.org/App_Content/ahri/files/STANDARDS/AHRI/AHRI_Standard_210-240_2017.pdf
5. IECC 2015: International Energy Conservation Code 2015
   Available from: https://codes.iccsafe.org/public/document/IECC2015/chapter-4-ce-commercial-energy-efficiency
6. CEE High Efficiency Commercial Air Conditioning and Heat Pumps Initiative, Appendix B, Unitary Heat Pump Specification, Effective 1/1/2019 (accessed November 27, 2018)
   Available from:
   https://library.cee1.org/system/files/library/13655/Final_2018_CEE_HECAC_Initiative_Description.pdf
7. ENERGY STAR® Program Requirements Product Specification for Geothermal Heat Pumps Eligibility Criteria Version 3.1, Rev. March 2012
   Available from:
   https://www.energystar.gov/sites/default/files/specs//private/Geothermal_Heat_Pumps_Program_Requirements%20v3.1.pdf

Record of Revision

Record of Revision Number	Issue Date
12-18-12	12/28/2018

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INFRARED HEATERS

Measure Description

This measure covers the installation of gas-fired, low-intensity infrared (IR) heaters, replacing existing gas-fired furnaces and warm air unit heaters in commercial and industrial facilities. Low-intensity IR heaters, also referred to as radiant tube heaters, operate through the combustion of fuel to heat steel or ceramic emitter tubes that deliver infrared radiant energy to the space. IR heaters operate through radiant rather than convective heat transfer, making them ideally suited for spaces with high air exchange rates (i.e. commercial garages and loading docks). Low-intensity IR heaters have radiating surfaces that typically operate at less than 732°C (1,350°F).

Method for Calculating Annual Energy and Peak Coincident Demand Savings[679]

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{unit} \times \frac{EFLH_{heating}}{100} \times \left(1 - \frac{HDD_{55}/(55 - T_{design})}{HDD_{65}/(65 - T_{design})}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$kBTU/h_{in}$	= Fuel input rating of the installed equipment
$EFLH_{heating}$	= Heating equivalent full-load hours
ESF	= Energy Savings Factor
HDD_{55}	= Heating Degree Days of the climate zone with a 55-degree base
HDD_{65}	= Heating Degree Days of the climate zone with a 65-degree base
T_{design}	= Equipment design temperature
100	= Conversion factor, one therm equals 100 kBTU
55	= Assumed space temperature in the efficient case (°F)
65	= Assumed space temperature in the baseline case (°F)

679 The derivation of savings is based on the reduced input capacity requirement with the radiant heating of an IR Heater (efficient) as opposed to convective heating of a conventional heating system (baseline). The thermal efficiency is assumed to be equivalent between the baseline and efficient case.

Summary of Variables and Data Sources

Variable	Value	Notes
$(kBTU/h)_{in}$/unit		Nameplate input rating of the efficient unit, from application
$EFLH_{heating}$		From application. If unknown, lookup based on building type and location from Appendix G
HDD_{55}		Lookup from Location Variables table below for 55-degree base based on location.
HDD_{65}		Lookup from Location Variables table below for 65-degree base based on location.
T_{design}		Lookup from Location Variables table below based on location.

Location Variables

City	HDD_{55}[680]	HDD_{65}[681]	T_{design}[682]
Albany	4,255	6,680	-0.3
Binghamton	4,624	7,193	0.0
Buffalo	4,180	6,617	3.5
Massena	5,556	8,196	-8.7
NYC	2,576	4,671	14.3
Poughkeepsie	3,833	6,210	2.7
Syracuse	4,223	6,651	-0.7

Coincidence Factor (CF)

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

Baseline Efficiencies From Which Savings are Calculated

The baseline condition is a minimally code-compliant gas-fired furnace or warm air unit heater.

Compliance Efficiencies From Which Incentives are Calculated

The compliance condition is a low-intensity, gas-fired infrared or radiant tube heater. The methodology prescribed assumes a 10°F reduction to maintain occupant comfort in the affected space.[683]

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

680 National Oceanic and Atmospheric Administration, National Climatic Data Center, 1981-2010 Normals
681 Ibid
682 2017 ASHRAE Handbook – Fundamentals, Appendix: Design Conditions for Selected Locations, Heating Dry Bulb 99.6%
683 2012 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 16, Infrared Radiant Heating

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

IR heaters transmit radiant heat, eliminating fan motor load requirements associated with distribution of heated air in convective heating systems. This impact is not considered in the methodology above at this time.

References

1. 2017 ASHRAE Handbook – Fundamentals, Appendix: Design Conditions for Selected Locations
2. 2012 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 16, Infrared Radiant Heating
3. National Oceanic and Atmospheric Administration, National Climatic Data Center, 1981-2010 Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals

Record of Revision

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12-18-11	12/28/2018

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Variable Refrigerant Flow Systems

Measure Description

This measure covers the installation of high-efficiency Variable Refrigerant Flow (VRF) Systems, as defined below, in commercial applications including multifamily buildings of four or more stories[684] or with an occupied floor located more than 75 feet above the lowest level of fire department vehicle access[685]. In both replacement and new construction/major renovation projects, the baseline case shall be minimally code compliant equipment of the same type and capacity as in the efficient case, which shall be sized in accordance with federal, state and local code.

Variable Refrigerant Flow (VRF) System
An engineered direct exchange (DX) multi-split system incorporating at least one variable capacity compressor distributing refrigerant through a piping network to multiple indoor fan coil units each capable of individual zone temperature control, through proprietary zone temperature control devices and common communications network. Variable refrigerant flow implies three or more steps of control on common, inter-connecting piping.

VRF Multi-Split System
A split system air-conditioner or heat pump incorporating a single refrigerant circuit, with one or more outdoor units, at least one variable speed compressor or an alternative compressor combination for varying the capacity of the system by three or more steps, multiple indoor fan coil units, each of which is individually metered and individually controlled by a proprietary control device and common communications network. The system shall be capable of operating either as an air conditioner or a heat pump. Variable refrigerant flow implies three or more steps of control on common, inter-connecting piping.

VRF Heat Recovery Multi-Split System
A split system air-conditioner or heat pump incorporating a single refrigerant circuit, with one or more outdoor units at least one variable-speed compressor or an alternate compressor combination for varying the capacity of the system by three or more steps, multiple indoor fan coil units, each of which is individually metered and individually controlled by a proprietary control device and common communications network. This system is capable of operating as an air-conditioner or as a heat pump. The system is also capable of providing simultaneous heating and cooling operation, where recovered energy from the indoor units operating in one mode can be transferred to one or more.[686]

684 NYSERDA, Mid- and High-Rise Multifamily Buildings
685 IBC 2015; Chapter 2 Definitions: High-Rise Building
686 AHRI Standard 1230 - 2010 Standard for Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

For Air-Cooled Units with Cooling Capacity <65,000 BTU/h

$$\Delta kWh = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) \times EFLH_{cooling} + \frac{kBTU/h}{unit} \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}\right]$$

For Air-Cooled Units with Cooling Capacity ≥65,000 BTU/h

$$\Delta kWh = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{IEER_{baseline}} - \frac{12}{IEER_{ee}}\right) \times EFLH_{cooling} + \frac{(kBTU/h)/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right]$$

For Water-Cooled Units

$$\Delta kWh = units \times \left[\frac{tons}{unit} \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times EFLH_{cooling} + \frac{(kBTU/h)/unit}{3.412} \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times EFLH_{heating}\right]$$

Peak Coincident Demand Savings

$$\Delta kW = \frac{tons}{unit} \times \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons	= Output cooling capacity in tons (at AHRI standard rating conditions)
kBTU/h	= Output heating capacity in kBTU/h (at AHRI standard high-temperature rating conditions)

baseline = Baseline condition or measure
ee = Energy efficient condition or measure
SEER = Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling in BTU, divided by the total electric energy input during the same period in watt-hours (used only for units with cooling capacity <65,000 BTU/h).
IEER = Integrated energy efficiency ratio in BTU/watt-hour. A weighted calculation of mechanical cooling efficiencies at full load and part load AHRI standard rating conditions (used only for units with cooling capacity ≥65,000 BTU/h)
EER = Energy efficiency ratio under peak conditions in BTU/watt-hour. Measurement of the cooling capacity for a unit in BTU/h divided by the connected electric power of the unit in watts (at AHRI standard rating conditions)
HSPF = Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric strip heat) during the heating season divided by the total electric energy heat pump consumed in watt-hours (used only for units with cooling capacity <65,000 BTU/h)
COP = Coefficient of performance, ratio of output energy/input energy (at AHRI standard high-temperature rating conditions) (used only for units with cooling capacity ≥65,000 BTU/h)
$EFLH_{cooling}$ = Cooling equivalent full-load hours
$EFLH_{heating}$ = Heating equivalent full-load hours
CF = Coincidence factor
12 = (kBTU/h)/ton of air conditioning capacity
3.412 = Conversion factor, one watt-h equals 3.412 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application.
kBTU/h		From application.
$SEER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
$SEER_{ee}$		From application.
$HSPF_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
$HSPF_{ee}$		From application.
$IEER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
$IEER_{ee}$		From application.
$COP_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
COP_{ee}		From application.
$EER_{baseline}$		Lookup from Baseline Efficiencies table below based on equipment type, size category and applicable code.
EER_{ee}		From application.

Variable	Value	Notes
$EFLH_{heating}$		From application. If unknown, lookup based on building type and location from Appendix G.
$EFLH_{cooling}$		From application. If unknown, lookup based on building type and location from Appendix G.
CF	0.8	

The **SEER** is an estimate of the seasonal energy efficiency for an average US city for small units <65,000 BTU/h cooling output.

The **EER** is the rated full-load efficiency of the unit. It is used to estimate the efficiency of the unit under peak summer conditions.

The **IEER** is a weighted calculation of mechanical cooling efficiencies at full load and part load AHRI Standard Rating Conditions. Larger units are rated in IEER.

The **COP** is a ratio of the heating capacity in watts to the power input value in watts at any given set of AHRI Standard Rating Conditions.

The **HSPF** is the average space heating system efficiency during the space heating season in BTU/watt-hour for small units <65,000 BTU/h cooling output.

Coincidence Factor (CF)

The prescribed value for the coincidence factor in the cooling mode is 0.8[687]

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for electrically operated Variable Refrigerant Flow Systems is defined by The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2013[688] or applicable code if higher, including but not limited to NYCECC 2016[689]. EER requirements are not specified by ASHRAE 90.1 for equipment with <65,000 BTU/h cooling capacity. For this equipment, baseline EER are established as follows[690]:

$$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$$

[687] *No source specified – update pending availability and review of applicable references.*
[688] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2013, Table 6.8.1-9 & Table 6.8.1-10
[689] NYCECC 2016, Table C403.2.3(11) and Table C403.2.3(12)
[690] DOE, Building America House Simulation Protocols, October 2010

Electrically Operated Variable-Refrigerant-Flow Air Conditioners						
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**ASHRAE 90.1 – 2013**	**NYCECC 2016** (as of 1/1/17)	**Test Procedure**
VRF air conditioners, air cooled	< 65,000 BTU/h	All	VRF Multisplit System	13.0 SEER	13.0 SEER	AHRI 1230
	≥ 65,000 BTU/h and < 135,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	11.2 EER 13.1 IEER	11.2 SEER 15.5 IEER	
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	11.0 EER 12.9 IEER	11.0 EER 14.9 IEER	
	≥ 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	10.0 EER 11.6 IEER	10.0 EER 13.9 IEER	

Electrically Operated Variable-Refrigerant-Flow Heat Pumps						
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**ASHRAE 90.1 – 2013**	**NYCECC 2016** (as of 1/1/17)	**Test Procedure**
VRF air conditioners air cooled	< 65,000 BTU/h	All	VRF Multisplit System	13.0 SEER	13.0 SEER	AHRI 1230
	≥ 65,000 BTU/h and < 135,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	11.0 EER 12.9 IEER	11.0 EER 14.6 IEER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	Electric resistance (or none)	VRF Multisplit System with heat recovery	10.8 EER 12.7 IEER	10.8 EER 14.4 IEER	
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	10.6 EER 12.3 IEER	10.6 EER 13.9 IEER	
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System with heat recovery	10.4 EER 12.1 IEER	10.4 EER 13.7 IEER	
	≥ 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	9.5 EER 11.0 IEER	9.5 EER 12.7 IEER	
	≥ 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System with heat recovery	9.3 EER 10.8 IEER	9.3 EER 12.5 IEER	

Electrically Operated Variable-Refrigerant-Flow Heat Pumps						
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**ASHRAE 90.1 – 2013**	**NYCECC 2016** (as of 1/1/17)	**Test Procedure**
VRF water source (cooling mode)	< 65,000 BTU/h	All	VRF multisplit systems with 86°F entering water	12.0 EER	12.0 EER	AHRI 1230
	< 65,000 BTU/h	All	VRF multisplit systems with heat recovery 86°F entering water	11.8 EER	11.8 EER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	All	VRF multisplit systems with 86°F entering water	12.0 EER	12.0 EER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	All	VRF multisplit systems with heat recovery 86°F entering water	11.8 EER	11.8 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with 86°F entering water	10.0 EER	10.0 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with heat recovery 86°F entering water	9.8 EER	9.8 EER	
VRF groundwater source (cooling mode)[691]	< 135,000 BTU/h	All	VRF multisplit systems with 59°F entering water	16.2 EER	16.2 EER	AHRI 1230
	< 135,000 BTU/h	All	VRF multisplit systems with heat recovery 59°F entering water	16.0 EER	16.0 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with 59°F entering water	13.8 EER	13.8 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with heat recovery 59°F entering water	13.6 EER	13.6 EER	

[691] An error was identified in which NYCECC Table 6.8.1-10 reversed the titles of VRF ground source (cooling mode) and VRF groundwater source (cooling mode). The titles are corrected here, aligning with ASHRAE 90.1-2013 requirements.

Electrically Operated Variable-Refrigerant-Flow Heat Pumps						
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**ASHRAE 90.1 – 2013**	**NYCECC 2016** (as of 1/1/17)	**Test Procedure**
VRF ground source (cooling mode) [692]	< 135,000 BTU/h	All	VRF multisplit systems with 77°F entering water	13.4 EER	13.4 EER	AHRI 1230
	< 135,000 BTU/h	All	VRF multisplit systems with heat recovery 77°F entering water	13.2 EER	13.2 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with 77°F entering water	11.0 EER	11.0 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with heat recovery 77°F entering water	10.8 EER	10.8 EER	
VRF air cooled (heating mode)	< 65,000 BTU/h (cooling capacity)	-	VRF multisplit systems	7.7 HSPF	7.7 HSPF	AHRI 1230
	≥ 65,000 BTU/h and < 135,000 BTU/h	-	VRF multisplit systems 47°F db/43°F wb outdoor air	3.3 COP_H	3.3 COP_H	
		-	17°F db/15°F wb outdoor air	2.25 COP_H	2.25 COP_H	
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems 47°F db/43°F wb outdoor air	3.2 COP_H	3.2 COP_H	
		-	17°F db/15°F wb outdoor air	2.05 COP_H	2.05 COP_H	
VRF water source (heating mode)	< 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 68°F entering water	4.2 COP_H	4.2 COP_H	AHRI 1230
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 68°F entering water	3.9 COP_H	3.9 COP_H	
VRF groundwater source (heating mode)	< 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 50°F entering water	3.6 COP_H	3.6 COP_H	AHRI 1230
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 50°F entering water	3.3 COP_H	3.3 COP_H	
VRF ground source (heating mode)	< 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 32°F entering water	3.1 COP_H	3.1 COP_H	AHRI 1230
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 32°F entering water	2.8 COP_H	2.8 COP_H	

[692] An error was identified in which NYCECC Table 6.8.1-10 reversed the titles of VRF ground source (cooling mode) and VRF groundwater source (cooling mode). The titles are corrected here, aligning with ASHRAE 90.1-2013 requirements.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a high efficiency variable refrigerant flow system as defined in the Measure Description section above with an efficiency of at least 10% more than that required by ASHRAE 90.1 – 2013, an election outlined in ECCCNYS Additional Efficiency Package Options[693](see table below for reference). Where +10% ASHRAE 90.1 – 2013 is less stringent than applicable local code, VRF efficiency must exceed code.

Electrically Operated Variable-Refrigerant-Flow Air Conditioners					
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**+10% ASHRAE 90.1 – 2013**	**Test Procedure**
VRF air conditioners, air cooled	< 65,000 BTU/h	All	VRF Multisplit System	14.3 SEER	AHRI 1230
	≥ 65,000 BTU/h and < 135,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	12.3 EER 14.4 IEER	
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	12.1 EER 14.2 IEER	
	≥ 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	11.0 EER 12.8 IEER	

Electrically Operated Variable-Refrigerant-Flow Air to Air and Applied Heat Pumps					
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**+10% ASHRAE 90.1 – 2013**	**Test Procedure**
VRF air conditioners air cooled	< 65,000 BTU/h	All	VRF Multisplit System	14.3 SEER	AHRI 1230
	≥ 65,000 BTU/h and < 135,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	12.1 EER 14.2 IEER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	Electric resistance (or none)	VRF Multisplit System with heat recovery	11.9 EER 14.0 IEER	
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	11.7 EER 13.5 IEER	
	≥ 135,000 BTU/h and < 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System with heat recovery	11.4 EER 13.3 IEER	
	≥ 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System	10.5 EER 12.1 IEER	
	≥ 240,000 BTU/h	Electric resistance (or none)	VRF Multisplit System with heat recovery	10.2 EER 11.9 IEER	
VRF water source (cooling mode)	< 65,000 BTU/h	All	VRF multisplit systems with 86°F entering water	13.2 EER	AHRI 1230
	< 65,000 BTU/h	All	VRF multisplit systems with heat recovery 86°F entering water	13.0 EER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	All	VRF multisplit systems with 86°F entering water	13.2 EER	
	≥ 65,000 BTU/h and < 135,000 BTU/h	All	VRF multisplit systems with heat recovery 86°F entering water	13.0 EER	

693 ECCCNYS 2016; SECTION C406.2

Electrically Operated Variable-Refrigerant-Flow Air to Air and Applied Heat Pumps					
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**+10% ASHRAE 90.1 – 2013**	**Test Procedure**
VRF water source (cooling mode)	≥ 135,000 BTU/h	All	VRF multisplit systems with 86°F entering water	11.0 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with heat recovery 86°F entering water	10.8 EER	
VRF groundwater source (cooling mode)	< 135,000 BTU/h	All	VRF multisplit systems with 59°F entering water	17.8 EER	AHRI 1230
	< 135,000 BTU/h	All	VRF multisplit systems with heat recovery 59°F entering water	17.6 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with 59°F entering water	15.2 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with heat recovery 59°F entering water	15.0 EER	
VRF ground source (cooling mode)	< 135,000 BTU/h	All	VRF multisplit systems with 77°F entering water	14.7 EER	AHRI 1230
	< 135,000 BTU/h	All	VRF multisplit systems with heat recovery 77°F entering water	14.5 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with 77°F entering water	12.1 EER	
	≥ 135,000 BTU/h	All	VRF multisplit systems with heat recovery 77°F entering water	11.9 EER	
VRF air cooled (heating mode)	< 65,000 BTU/h (cooling capacity)	-	VRF multisplit systems	8.5 HSPF	AHRI 1230
	≥ 65,000 BTU/h and < 135,000 BTU/h	-	VRF multisplit systems 47°F db/43°F wb outdoor air	3.6 COP_H	
		-	17°F db/15°F wb outdoor air	2.5 COP_H	
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems 47°F db/43°F wb outdoor air	3.5 COP_H	
		-	17°F db/15°F wb outdoor air	2.3 COP_H	
VRF water source (heating mode)	< 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 68°F entering water	4.6 COP_H	AHRI 1230
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 68°F entering water	4.3 COP_H	

Electrically Operated Variable-Refrigerant-Flow Air to Air and Applied Heat Pumps					
Equipment Type	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**+10% ASHRAE 90.1 – 2013**	**Test Procedure**
VRF groundwater source (heating mode)	< 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 50°F entering water	4.0 COP_H	AHRI 1230
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 50°F entering water	3.6 COP_H	
VRF ground source (heating mode)	< 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 32°F entering water	3.4 COP_H	AHRI 1230
	≥ 135,000 BTU/h (cooling capacity)	-	VRF multisplit systems with 32°F entering water	3.1 COP_H	

Operating Hours

Equipment heating and cooling equivalent full load hours shall be taken from the application. If unknown, default EFLH by facility type and location can be found in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYSERDA, Mid- and High-Rise Multifamily Buildings
   Available from: https://www.nyserda.ny.gov/All-Programs/Programs/Low-Rise-Residential/Mid-and-High-Rise-Multifamily-Buildings
2. IBC 2015: Chapter 2 Definitions
   Available from: https://codes.iccsafe.org/content/IBC2015NY1/chapter-2-definitions
3. AHRI Standard 1230 - 2010 Standard for Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment
   Available from: http://www.ahrinet.org/App_Content/ahri/files/standards%20pdfs/AHRI%20standards%20pdfs/AHRI%20Standard%201230%20-%202010.pdf
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2013
   Available from: https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

5. IECC 2015: International Energy Conservation Code 2015
   Available from: https://codes.iccsafe.org/public/document/IECC2015/chapter-4-ce-commercial-energy-efficiency
6. Building America House Simulation Protocols, Robert Hendron and Cheryn Engebrecht, National Renewable Energy Laboratory, October 2010
   Available from: https://www.nrel.gov/docs/fy11osti/49246.pdf
7. NYCECC 2016; Table C403.2.3(11) Electrically Operated Variable-Refrigerant-Flow Air Conditioners & Table C403.2.3(12) Electrically Operated Variable-Refrigerant-Flow Air-to-Air and Applied Heat Pumps
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
8. ECCCNYS 2016; Section C406.2 More efficient HVAC equipment performance
   Available from: https://codes.iccsafe.org/content/IECC2015/chapter-4-ce-commercial-energy-efficiency?site_type=public

Record of Revision

Record of Revision Number	Issue Date
12-18-13	12/28/2018

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTAT – WI-FI (COMMUNICATING)

Measure Description

This section covers Wi-Fi communicating thermostats without behavioral learning capability applied to small commercial buildings with natural gas heat boilers or furnaces, electric heat pumps, electric resistance heating or central air conditioners. These communicating thermostats allow set point adjustment via a remote application.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings (Cooling)

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh/unit	104	Annual electric savings per installed thermostat, in kWh[694]
ΔkW/unit	0.23	Peak demand savings per installed thermostat, in kW[695]
Δtherms/unit	66	Annual gas savings per installed thermostat, in therms[696]

Coincidence Factor (CF)

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

[694] Cadmus Group, Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation, September 2012
[695] Ibid.
[696] Ibid.

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

HVAC system operating hours are embedded in the deemed savings values associated with Wi-Fi communicating thermostats, which are based on metering results.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Cadmus Group, Inc. (September 2012), *"Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation"*, prepared for The Electric and Gas Program Administrators of Massachusetts.
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/Wi-Fi-Programmable-Controllable-Thermostat-Pilot-Program-Evaluation_Part-of-the-Massachusetts-2011-Residential-Retrofit-Low-Income-Program-Area-Study.pdf
2. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: HV-ProgTStat.
   Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

Record of Revision Number	Issue Date
1-16-5	12/31/2015
9-17-4	9/30/2017

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THERMOSTATIC RADIATOR VALVES

Measure Description

This measure covers the installation of thermostatic radiator valves (TRVs) on one- and two-pipe space heating steam systems in commercial facilities. TRVs are self-regulating valves that require no ancillary power and provide local control of room air temperature by modulating the flow of steam into radiators. In one-pipe steam systems, this is accomplished by installing TRVs on radiator air vents. When in the closed position, the TRV prevents the venting of air, thereby restricting the flow of steam into the radiator. In two-pipe systems, TRVs are installed on the radiator inlets, preventing the intake of steam when closed. This measure is not applicable to district or municipal steam systems.

TRVs demonstrate the greatest potential for energy savings and financial viability when overheating is exhibited in zones throughout the system and when combined with other steam system best practices improvements. Therefore, prioritization of this measure is recommended in zones that are overheated by 3°F or greater[697] and is only eligible for energy savings when installed as part of system inspection, balancing and commissioning including, but not limited to: burner tuning, boiler cleaning, recalibration of boiler control set points, inspection and repair/replacement of leaking inlets and air vents, installation of properly sized air vents, main line steam trap repair/replacement, recalibration of system operating pressure, insulation of bare steam lines and installation of radiator orifice plates in two-pipe systems.[698] If the system undergoes regular maintenance, savings may be claimed upon program confirmation that the system is in proper working order.

Method for Calculating Annual Energy Savings and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

where:

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

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

698 US DOE, Thermostatic Radiator Valve Evaluation, January 2015, pg. 25 - 26

Δtherms/HDD = Annual gas energy savings per Heating Degree Day (HDD) per TRV
HDD_{loc} = Heating Degree Days based on location

Summary of Variables and Data Source

Variable	Value	Notes
Δtherms/HDD	One-pipe: 0.004589 Two-pipe: 0.005983	NYSERDA[699, 700]
HDD_{loc}		Look up based on location from Heating Degree Days section below

<u>Heating Degree Days</u>
For the purposes of this measure, Heating Degree Days are defined as the number of degrees that a day's average temperature is below some baseline temperature, which represents the temperature below which buildings need to be heated. The HDD values listed in the table below are based on 30-year averages of U.S annual climate normals between 1981 and 2010 using base 65° F.[701]

City	HDD_{loc}
Albany	6,680
Binghamton	7,193
Buffalo	6,617
Massena	8,196
NYC	4,671
Poughkeepsie	6,210
Syracuse	6,651

Coincidence Factor (CF)

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

699 Results of multifamily impact evaluation used as a proxy to estimate commercial facility savings; average of three test sites implementing full installation (Phase 3) of TRVs as reported in: NYSERDA, Thermostatic Radiator Valve (TRV) Demonstration Project, Report No. 95-14, September 1995, Table 2-2: Heating Plant Characteristics, pg. 2-2, Table 2-3: TRV Installation, pg. 2-6 and Table 3-5, pg, 3-6. Annual gas energy savings figure was derived by multiplying the ratio of the number of apartments per building to the number of TRVs per building to the difference in energy consumption per apartment per degree day between Phase 1 and Phase 3.
700 Results of multifamily impact evaluation used as a proxy to estimate commercial facility savings; average of three test sites implementing installation of TRVs (Group C) as reported in: T. Cholewa, A. Siuta-Olcha, C.A. Balaras, Actual Energy Savings from the Use of Thermostatic Radiator Valves in Residential Buildings–Long Term Field Evaluation, Energy and Buildings, July 2017, Table 1, pg. 488 and Table 4, pg. 492, normalized to 3,825 HDD (cited value for test site location). Annual gas energy savings figure was derived by multiplying the ratio of the total heated floor surface area per building to the number of radiators per building to the difference in energy consumption per building per square meter and dividing by heating degree days.
701 HDD taken from NCEI 1981-2010 climate normals

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a radiator in a one- or two-pipe space heating commercial steam system with manual control valves.

Compliance Efficiency from which Savings are Calculated

The compliance condition is a radiator equipped with thermostatic radiator valve in a one- or two-pipe space heating commercial steam system that has undergone system inspection, balancing and commissioning as detailed in the Measure Description section above.

Operating Hours

Operating hours are embedded in the prescribed values for energy savings per heating degree day and are therefore not explicitly defined for this measure.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. NYSERDA, Thermostatic Radiator Valve (TRV) Demonstration Project, Report No. 95-14, September 1995
   Available from:
   https://digital.library.unt.edu/ark:/67531/metadc620708/m2/1/high_res_d/119941.pdf
2. US DOE, Thermostatic Radiator Valve Evaluation, January 2015
   Available from: https://www.nrel.gov/docs/fy15osti/63388.pdf
3. T. Cholewa, A. Siuta-Olcha, C.A. Balaras, Actual Energy Savings from the Use of Thermostatic Radiator Valves in Residential Buildings–Long Term Field Evaluation, Energy and Buildings, July 2017
   Available from:
   https://www.sciencedirect.com/science/article/pii/S0378778817305820?viewFullText=true#bib0100
4. NOAA National Centers for Environmental Information – 1981-2010 Normals
   Available from: http://www.ncdc.noaa.gov/cdo-web/datatools/normals

Record of Revision

Record of Revision Number	Issue Date
12-18-16	12/28/2018

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DEMAND CONTROL VENTILATION (DCV)

Measure Description

Demand control ventilation systems have the capability to automatically reduce the outdoor air intake below design rates when occupancy of spaces served by the system is less than design occupancy. Typically, this is controlled by a carbon dioxide sensor, occupancy sensor or turnstile counter. Demand control ventilation systems save energy by reducing the amount of outside air which requires heating or cooling.

This measure assumes a demand control ventilation system with CO_2 sensors will be added to an existing HVAC system with natural gas heating that previously had no DCV system or ventilation heat recovery equipment installed. The as-built condition must comply with all applicable provisions of federal, state and local mechanical/ventilation and construction code, including but not limited to section C403.2.6.1 of ECCCNYS and NYCECC and section 402 of NYS and NYC Mechanical Code (IMC). Deemed savings factors associated with the heating side of heat pumps are under development and will be included in a future revision.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \frac{ft^2}{1{,}000} \times ESF_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = \frac{ft^2}{1{,}000} \times ESF_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
ft^2	= Total square footage of the conditioned space impacted by the measure
$ESF_{cooling}$	= Energy savings factor for cooling (kWh/1,000 ft^2)
$ESF_{heating}$	= Energy savings factor for heating (therms/1,000 ft^2)
1,000	= Conversion to 1,000 ft^2

Summary of Variables and Data Sources

Variable	Value	Notes
ft^2		From application.
$ESF_{cooling}$		Lookup from $ESF_{cooling}$ table below based on location and building type.
$ESF_{heating}$		Lookup from $ESF_{heating}$ table below based on location and building type.

$ESF_{cooling}$[702]

kWh/1,000 ft²							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	273	176	248	181	555	292	262
Office - Mid-rise (4 to 11 Stories)	258	166	235	171	525	276	248
Office - High-rise (12+ Stories)	269	174	245	178	548	288	259
Religious Building	305	196	277	202	620	326	292
Restaurant	308	199	280	204	627	330	296
Retail - Department Store	374	241	340	248	761	400	359
Retail - Strip Mall	225	145	205	149	458	241	216
Convenience Store	361	233	328	239	734	386	346
Elementary School	196	126	178	130	398	209	188
High School	189	122	172	125	385	202	182
College/ University	245	158	223	163	499	262	236
Healthcare Clinic	214	138	195	142	436	229	206
Lodging (Hotel/Motel)	346	223	315	229	704	370	332
Manufacturing	289	186	262	191	587	309	277
Special Assembly Auditorium	256	165	232	169	520	273	245
Other	274	177	249	182	558	293	263

$ESF_{heating}$[703]

Therms/1,000 ft²							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Office - Low-rise (1 to 3 Stories)	29	31	29	22	20	19	29
Office - Mid-rise (4 to 11 Stories)	19	21	19	14	13	12	19
Office - High-rise (12+ Stories)	26	28	25	20	18	17	26
Religious Building	189	204	187	144	131	123	189
Restaurant	136	147	135	104	95	89	137
Retail - Department	47	51	47	36	33	30	47

702 Deemed savings calculated based on IL TRM values for Chicago, adjusted by the ratio of Cooling Degree Days for each listed NY city and Chicago.
703 Deemed savings calculated based on IL TRM values for Chicago, adjusted by the ratio of Heating Degree Days for each listed NY city and Chicago.

Therms/1,000 ft^2							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Store							
Retail - Strip Mall	30	33	30	23	21	20	30
Convenience Store	23	25	23	18	16	15	24
Elementary School	82	88	81	62	57	53	82
High School	79	86	79	61	55	52	80
College/ University	158	170	156	120	109	102	158
Healthcare Clinic	56	60	55	43	39	36	56
Lodging (Hotel/Motel)	26	28	25	20	18	17	26
Manufacturing	21	23	21	16	15	14	21
Special Assembly Auditorium	221	239	219	169	154	144	222
Other	76	82	75	58	53	49	76

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline system is an existing natural gas heated return air system with no demand control ventilation or ventilation heat recovery equipment installed.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a DCV system added to the return air system to supply air based on occupancy demands.

Operating Hours

N/A

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. ECCCNYS 2016, per IECC 2015; C403.2.6 Ventilation
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016; C403.2.6 Ventilation
   Available from: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
3. IMC NYS 2015; 402 Natural Ventilation
   Available from: https://codes.iccsafe.org/public/document/IMC2015NY-1/chapter-4-ventilation
4. IMC NYC 2014: 402 Natural Ventilation
   Available from: https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_MC_Chapter4_Ventilation.pdf&section=conscode_2014
5. $ESF_{cooling}$ and $ESF_{heating}$ factors were calculated from the IL TRM Version 6.0, February 8, 2017, values of Chicago by creating a ratio of Cooling/Heating Degree Days between the NY weather cities and Chicago CDD/HDD and multiplying by the Chicago $SF_{cooling}$/$SF_{heating}$ respectively
   Available from: http://www.ilsag.info/il_trm_version_6.html

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6-17-15	6/30/2017
6-18-11	6/26/2018

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Outdoor Temperature Setback Control for Hydronic Boiler

Measure Description

This measure covers the installation of outdoor temperature setback control for commercial building gas boilers. Outdoor air setback control adjusts the hot water set point temperature of the boiler in response to outdoor air temperature. This measure is only applicable to retrofit of existing boilers in space heating systems. One outdoor temperature setback measure may be applied to each boiler.

This measure is not applicable to process boilers or boilers that serve DHW through an indirect system or boiler coil. Additionally, this measure is not applicable for boilers where hot water temperature is maintained regardless of heating load.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTU/h_{in}}{100} \times EFLH_{heating} \times ESF$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
$kBTU/h_{in}$ = Gas input rating (kBTU/h) of the controlled boiler
$EFLH_{heating}$ = Equivalent full-load heating hours
ESF = Energy Savings Factor
100 = Conversion factor, one therm equals 100 kBTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTU/h_{in}$		From application.
$EFLH_{heating}$		Look up based on building type, vintage and location in Appendix G.

Variable	Value	Notes
ESF	0.05	GDS Associates, Inc. [704]

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline condition is an existing commercial boiler without outdoor temperature setback control.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an existing commercial boiler equipped with outdoor temperature setback control.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical multi-family and other commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for C&I buildings in NY by location, building type and vintage are tabulated in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Lower boiler set point temperatures may cause hot water circulators to run longer cycles. This impact is anticipated to be minor and is not quantified in this measure.

References

1. GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks.
   Available from: http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
2. Boiler Reset Control. Energy Solutions Center.
   Available from: http://cleanboiler.org/learn-about/boiler-efficiency-improvement/efficiency-index/boiler-reset-control/

[704] GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks, Table 6-4: Commercial Measure Characteristics; Energy Solutions Center

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12-18-15	12/28/2018

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STEAM TRAP REPAIR OR REPLACEMENT – LOW PRESSURE SPACE HEATING

Measure Description

Steam systems distribute heat from boilers to satisfy space heating, process, and commercial end-use requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements. This measure and calculations are applicable to steam traps served by gas fired boilers, for low-pressure (<15 psig) space heating. This measure does not apply to municipal steam systems.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to insure correct operation. Faulty steam traps (leaking or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam production. There are three major types of steam traps that are applicable: 1) thermostatic (including float and thermostatic), 2) mechanical and 3) thermodynamic.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = \text{units} \times Loss_{steam} \times \frac{\Delta H_{vap}}{E_t} \times \frac{EFLH_{heating}}{100{,}000}$$

$$Loss_{steam} = 24.24 \times Dia^2 \times P_a \times 0.5$$

$$P_a = psig + psia$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of steam traps repaired/replaced under the program
$Loss_{steam}$	= Hourly steam loss per failed trap (lb/hr)
24.24	= Steam loss constant per Napier's equation (lb/hr-psia-in^2)
Dia	= Internal Diameter (I.D.) of steam trap orifice
P_a	= Absolute steam pressure (psi)

0.5 = Percent of orifice open[705]
psig = Steam gage pressure (psi)
psia = Atmospheric pressure (psi)
ΔH_{vap} = Heat of vaporization (latent heat), in BTU/lb
E_t = Thermal efficiency of boiler
$EFLH_{heating}$ = Equivalent full-load heating hours
100,000 = Conversion from BTU to therms (100,000 BTU/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$	Calculated	Dependent upon system operating pressure (psig) and steam trap orifice diameter (D)
D	Variable	Steam trap orifice diameter (in), from application
P_a	Calculated	Dependent upon system operating pressure (psig)
psig	Variable	Steam boiler operating pressure (psi), from application
psia	14.7	Atmospheric pressure (psi)
ΔH_{vap}	Lookup	Lookup from table below based on system operating pressure (psig)
E_t	Variable	Boiler thermal efficiency, from application
$EFLH_{heating}$	Lookup	Lookup based on building type and location in Appendix G.

Heat of Vaporization (BTU/lb)[706]

Pressure (psig)	Heat of Vaporization (BTU/lb)
0	970
1	968
2	966
3	964
4	962
5	961
6	959
7	957
8	956
9	954
10	953
11	951
12	950
13	948
14	947
15	946

[705] Conservative estimate typically used by steam trap manufacturers/vendors to estimate savings; Enbridge adjustment factor used as referenced in CLEAResult “Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012 and DOE Federal Energy Management Program Steam Trap Performance Assessment.
[706] Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases (1936)

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

The baseline is assumed to be a steam trap failed open on a low-pressure steam space heating system.

Compliance Efficiency from which Incentives are Calculated

Replaced or repaired traps will no longer leak or blow-through after installation.

Operating Hours

Heating equivalent full-load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. Operating hour assumptions for the prototypical building models are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. Joseph Henry Keenan and Frederick G. Keyes, Thermodynamic Properties of Steam Including Data for the Liquid and Solid Phases, John Wiley and Sons, New York (1936)
2. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: HVAC-StmTrp Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

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GUEST ROOM ENERGY MANAGEMENT SYSTEM

Measure Description

This measure covers the installation of guest room energy management systems that control HVAC units for individual hotel and motel rooms based upon occupancy sensors, passive infrared or key cards that indicate room occupancy. Sensors controlled by a networked front desk system are not eligible.[707] During unoccupied periods[708], the default setting for controlled units must differ from the operating set point by at least five degrees Fahrenheit or shut the unit fan and heating/cooling off completely. In New York City, this measure is restricted to hotels and motels with 50 guest rooms or less.[709] The existing (baseline) HVAC system must be manually controlled within each guest room.

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{tons}{unit} \times ESF_{gas}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of guest rooms with energy management systems installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
$ESF_{electric}$	= Electric energy savings factor (kWh/ton)
DSF	= Demand savings factor (kW/ton)
ESF_{gas}	= Gas energy savings factor (therms/ton)

[707] A networked system controlled from the front desk is defined as a system capable of identifying reserved rooms according to a timed schedule and controlling HVAC in each guest room separately.
[708] An unoccupied room is defined as a guest room that has been continuously unoccupied for at least 30 minutes.
[709] NYC Local Law 91

Summary of Variables and Data Sources

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

$ESF_{electric}$[710]

kWh/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	359	230	327	218	697	403	343
Motel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	1122	718	1022	682	2179	1261	1071
Motel, PTAC w/ Gas Heating, Housekeeping Setback	36	23	33	22	70	41	35
Motel, PTAC w/ Gas Heating, No Housekeeping Setback	116	74	105	70	225	130	110
Motel, PTHP, Housekeeping Setback	150	96	136	91	291	168	143
Motel, PTHP, No Housekeeping Setback	566	362	516	344	1099	636	540
Hotel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	133	85	121	81	259	150	127
Hotel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	242	155	221	147	471	273	232
Hotel, PTAC w/ Gas Heating, Housekeeping Setback	84	54	77	51	164	95	81

[710] Deemed savings calculated based on IL TRM Version 7.0 values for Chicago, adjusted by the ratio of NCEI Cooling Degree Day 1981-2010 Normals for each listed NY city and Chicago O'Hare Airport (accessed 11/26/2018). IL TRM deemed savings derived through the simulation of hotel and motel models in EnergyPlus as informed by S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013. This source is not publicly available but is referenced by the IL TRM Version 7.0.

kWh/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Hotel, PTAC w/ Gas Heating, No Housekeeping Setback	138	88	126	84	269	155	132
Hotel, PTHP, Housekeeping Setback	103	66	94	63	200	116	98
Hotel, PTHP, No Housekeeping Setback	177	113	162	108	344	199	169
Hotel, Central Hot Water Fan Coil w/ Electric Resistance Heating, Housekeeping Setback	114	73	104	69	222	128	109
Hotel, Central Hot Water Fan Coil w/ Electric Resistance Heating, No Housekeeping Setback	208	133	190	127	405	234	199
Hotel, Central Hot Water Fan Coil w/ Gas Heating, Housekeeping Setback	65	42	59	40	127	73	62
Hotel, Central Hot Water Fan Coil w/ Gas Heating, No Housekeeping Setback	104	67	95	63	203	117	100

DSF[711]

kW/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	0.04	0.03	0.04	0.03	0.08	0.05	0.04
Motel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	0.12	0.08	0.11	0.07	0.23	0.14	0.12
Motel, PTAC w/ Gas Heating, Housekeeping Setback	0.04	0.03	0.04	0.03	0.08	0.05	0.04
Motel, PTAC w/ Gas Heating, No Housekeeping Setback	0.12	0.08	0.11	0.07	0.23	0.14	0.12

[711] Deemed savings calculated based on IL TRM Version 7.0 values for Chicago, adjusted by the ratio of NCEI Cooling Degree Day 1981-2010 Normals for each listed NY city and Chicago O'Hare Airport (accessed 11/27/2018). IL TRM deemed savings derived through the simulation of hotel and motel models in EnergyPlus as informed by S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013. This source is not publicly available but is referenced by the IL TRM Version 7.0.

kW/ton							
Building Type, HVAC Type, Housekeeping Setback	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTHP, Housekeeping Setback	0.04	0.03	0.04	0.03	0.08	0.05	0.04
Motel, PTHP, No Housekeeping Setback	0.12	0.08	0.11	0.07	0.23	0.14	0.12
Hotel, PTAC w/ Electric Resistance Heating, Housekeeping Setback	0.05	0.03	0.05	0.03	0.10	0.06	0.05
Hotel, PTAC w/ Electric Resistance Heating, No Housekeeping Setback	0.08	0.05	0.07	0.05	0.15	0.09	0.07
Hotel, PTAC w/ Gas Heating, Housekeeping Setback	0.05	0.03	0.05	0.03	0.10	0.06	0.05
Hotel, PTAC w/ Gas Heating, No Housekeeping Setback	0.08	0.05	0.07	0.05	0.15	0.09	0.07
Hotel, PTHP, Housekeeping Setback	0.05	0.03	0.05	0.03	0.10	0.06	0.05
Hotel, PTHP, No Housekeeping Setback	0.08	0.05	0.07	0.05	0.15	0.09	0.07
Hotel, Central Hot Water Fan Coil w/ Electric Resistance Heating, Housekeeping Setback	0.04	0.02	0.03	0.02	0.07	0.04	0.03
Hotel, Central Hot Water Fan Coil w/ Electric Resistance Heating, No Housekeeping Setback	0.05	0.03	0.05	0.03	0.10	0.06	0.05
Hotel, Central Hot Water Fan Coil w/ Gas Heating, Housekeeping Setback	0.04	0.02	0.03	0.02	0.07	0.04	0.03
Hotel, Central Hot Water Fan Coil w/ Gas Heating, No Housekeeping Setback	0.05	0.03	0.05	0.03	0.10	0.06	0.05

ESF_{gas}[712]

therms/ton							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Motel, PTAC w/ Gas Heating,	21.1	22.7	20.9	25.9	14.7	19.6	21.0

[712] Deemed savings calculated based on IL TRM Version 7.0 values for Chicago, adjusted by the ratio of NCEI Heating Degree Day 1981-2010 Normals for each listed NY city and Chicago O'Hare Airport (accessed 11/27/2018). IL TRM deemed savings derived through the simulation of hotel and motel models in EnergyPlus as informed by S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013. This source is not publicly available but is referenced by the IL TRM Version 7.0.

therms/ton							
Building Type	**Albany**	**Binghamton**	**Buffalo**	**Massena**	**NYC**	**Poughkeepsie**	**Syracuse**
Housekeeping Setback							
Motel, PTAC w/ Gas Heating, No Housekeeping Setback	65.3	70.3	64.7	80.2	45.7	60.7	65.0
Hotel, PTAC w/ Gas Heating, Housekeeping Setback	3.2	3.4	3.1	3.9	2.2	2.9	3.1
Hotel, PTAC w/ Gas Heating, No Housekeeping Setback	6.8	7.4	6.8	8.4	4.8	6.4	6.8
Hotel, Central Hot Water Fan Coil w/ Gas Heating, Housekeeping Setback	3.2	3.4	3.1	3.9	2.2	2.9	3.1
Hotel, Central Hot Water Fan Coil w/ Gas Heating, No Housekeeping Setback	6.8	7.4	6.8	8.4	4.8	6.4	6.8

Reference CDD and HDD Climate Normals[713]

Location	Cooling Degree Days (CDD)	Heating Degree Days (HDD)
Chicago (Reference)	842	6,340
Albany	597	6,680
Binghamton	382	7,193
Buffalo	544	6,617
Massena	363	8,196
New York City	1,160	4,671
Poughkeepsie	671	6,210
Syracuse	570	6,651

Coincidence Factor (CF)

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

[713] NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a hotel or motel guest room with a guest room energy management system that automatically adjusts room temperature by at least 5 degrees of operating set point based on room occupancy. Occupancy is detected by occupancy sensors or keycard sensors that automate temperature setback.

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

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

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

References

1. Local Laws of the City of New York for the year 2016, No. 91, 403.2.18 Automatic control of HVAC in hotel/motel guest rooms
   Available from: https://www1.nyc.gov/assets/buildings/local_laws/ll91of2016.pdf
2. 2019 Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 7.0. September 13, 2018 (accessed November 27, 2018)
   Available from:
   http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final/2019_IL-TRM_Version_7.0_dated_Sept-13-2018_Final_Volumes_1-4_Compiled.pdf
3. 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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LIGHTING

INTERIOR AND EXTERIOR LAMPS AND FIXTURES

Measure Description

This section covers energy-efficient lighting equipment, such as energy-efficient lamps, energy-efficient ballasts, compact fluorescent lamps, LED lamps, and improved lighting fixtures. Improved lighting fixtures may include reflectors and other optical improvements to lighting fixtures. These technologies, taken separately or combined into an energy-efficient lighting fixture, provide the required illumination at reduced input power.

Per EISA 2007, effective beginning January 1, 2020, if more stringent regulations are not put into effect by that date, the sale of general service lamps that do not meet a minimum efficiency standard of 45 lumens per watt will be prohibited.[714] Although baseline conditions for this measure are assumed to be the existing lighting wattage, this stipulation may still have a significant impact on estimated energy savings associated with replacement of general service lamps (20% - 70% depending on lumen output) beginning in 2020, particularly in cases where building code is triggered (new construction or renovations). This information is provided to inform future ETIP development.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times (1 + HVAC_c)$$

Peak Coincident Demand Savings

$$\Delta kW = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times HVAC_g$$

New construction, space renovations or remodels may require a building permit that includes compliance with local or state energy codes. In these instances, the applicable energy code defines the baseline. The energy consumption of the efficient and baseline lighting systems are defined in terms of the lighting power density (LPD) in watts per square foot. An alternate form of the lighting equations based on LDP is as follows:

[714] Energy Independence and Security Act of 2007. Pub. L. 110-140. Sec. 321. Efficient Light Bulbs H.R.6 – 89

Annual Electric Energy Savings

$$\Delta kWh = area \times \left[\frac{LPD_{baseline} - LPD_{ee}}{1{,}000}\right] \times hrs_{operating} \times (1 + HVAC_c)$$

Peak Coincident Demand Savings

$$\Delta kW = area \times \left[\frac{LPD_{baseline} - LPD_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = area \times \left[\frac{LPD_{baseline} - LPD_{ee}}{1{,}000}\right] \times hrs_{operating} \times HVAC_g$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures
CF = Coincidence factor
$_{ee}$ = Energy efficient condition or measure
$_{baseline}$ = Baseline condition or measure
area = Extent of space or surface
1,000 = Conversion factor, one kW equals 1,000 watts
LPD = Lighting power density
W = Watts
$hrs_{operating}$ = Lighting operating hours
$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor for peak demand at NYISO coincident summer peak hour
$HVAC_g$ = HVAC interaction factor for annual natural gas consumption (therms/kWh)

Summary of Variables and Data Sources

Variable	Value	Notes
$units_{baseline}$		Number of baseline measures, from application. Set equal to $Units_{ee}$ if unknown.
$units_{ee}$		Number of energy efficient measures installed under the program, from application.
$W_{baseline}$		Connected load of the baseline unit(s) displaced, from application (in Watts).
W_{ee}		Connected load of the energy-efficient unit, from application (in Watts).
$hrs_{operating}$		Lighting operating hours. From application or default, as listed below in the Operating Hours table.

Variable	Value	Notes
$LPD_{baseline}$		Lighting power density (in W/ft^2) for baseline measure, from application, based on NYS/NYC Energy Conservation code. New construction or major renovation (as defined by applicable code/permits) only.
LPD_{ee}		Lighting power density (in W/ft^2) for energy efficient measure, from application, based on installed system design. New construction or major renovation (as defined by applicable code/permits) only.
area		Floor area illuminated by lighting system (in ft^2)
$HVAC_c$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual electric energy consumption (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_d$	Exterior and Unconditioned Space: 0	HVAC interaction factor for peak demand at utility summer peak hour (dimensionless). Vintage and HVAC type weighted average by city. See Appendix D.
$HVAC_g$	Exterior and Unconditioned Space: 0	HVAC interaction factor for annual natural gas energy consumption (therms/kWh). Vintage and HVAC type weighted average by city. See Appendix D.
CF	Interior: 0 Exterior: 0	"Interior" designation extends to any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting.

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

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

Coincidence Factor (CF)

The prescribed coincidence factor for commercial indoor lighting measures is 1.0.[715] Since exterior lighting is generally off during daylight hours, the coincidence factor for exterior lighting is 0.0.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be the existing and operational lighting fixture in all

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

applications other than new construction or extensive renovations that trigger the building code. See table of standard fixture wattages in Appendix C. Note, depending on local codes, new construction, space renovations or remodels may require a building permit that includes compliance with local or state energy codes. In these instances, the applicable energy code defines the baseline.

Code LPD shall be taken from chapter C405.4: Interior Lighting Power Requirements (Prescriptive) and chapter 405.5: Exterior Lighting (Mandatory) of the Energy Conservation Construction Code of New York State[716] (ECCCNYS) and the New York City Energy Conservation Code[717] (NYCECC) that are based on IECC 2015. Alternatively, ASHRAE Standard 90.1-2013 may be referenced for compliance. In both cases, either the Building Area or Space-By-Space compliance path may be used.

Compliance Efficiency from which Incentives are Calculated

Compliance efficiency and fixture/lamp specifications shall be dictated by program eligibility criteria. See table of standard fixture wattages in Appendix C. Manufacturers' cut sheets may substitute for the standard fixture watts in Appendix C if available. In new construction or major renovation projects, the new lighting system power consumption should be expressed as a lighting power density (LPD) in watts per square foot.

Operating Hours

The average lighting operating hours are defined by building type, as shown in the table below. These are typical average values for the building types shown. Use building specific operating hours where available. For exterior lighting, the default annual operating hours are 4,380 hrs/yr (12 hours per day).

Facility Type	Lighting Hours (hrs/yr)	HVAC Int	Facility Type	Lighting Hours (hrs/yr)	HVAC Int
Auto Related[1]	2,810	AR	Manufacturing Facility	2,857	Ind
Automotive / Transportation Service or Repair Facility (24/7)	8,760	AR	Medical Offices	3,748	SOfc
Bakery	2,854	FS	Motion Picture Theatre	1,954	Asy
Banks	3,748	SOfc	Multi-Family (Common Areas)	7,665	MFL
Church	1,955	Rel	Museum	3,748	Asy
College– Cafeteria[2]	2,713	FS	Nursing Homes	5,840	MFL
College – Classes	2,586	CC	Office (General Office Types)[2]	3,013	SOfc/ LOfc
College - Dormitory	3,066	Dorm	Parking Garages	4,368	None
Commercial Condos[3]	3,100	SOfc	Parking Garages (24/7)	7,717	None

[716] ECCCNYS 2016; C405.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
[717] NYCECC 2016; C405.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)

Facility Type	Lighting Hours (hrs/yr)	HVAC Int	Facility Type	Lighting Hours (hrs/yr)	HVAC Int
Convenience Stores	6,376	SRet	Parking Lots	4,100	None
Convention Center	1,954	Asy	Penitentiary	5,477	MFL
Court House	3,748	LOfc	Performing Arts Theatre	2,586	Asy
Dining: Bar Lounge/Leisure	4,182	FS	Police / Fire Stations (24 Hr)	7,665	Asy
Dining: Cafeteria / Fast Food	6,456	FF	Post Office	3,748	SRet
Dining: Family	4,182	FS	Pump Stations	1,949	Ind
Entertainment	1,952	Asy	Refrigerated Warehouse	2,602	RWH
Exercise Center	5,836	SRet	Religious Building	1,955	Rel
Fast Food Restaurants	6,376	FF	Restaurants	4,182	FS
Fire Station (Unmanned)	1,953	Asy	Retail	3,463	SRet/ LRet
Food Stores	4,055	Gro	School / University	2,187	Univ
Gymnasium	2,586	Asy	Schools (Jr./Sr. High)	2,187	HS
Hospitals	7,674	Hosp	Schools (Preschool/Elementary)	2,187	Sch
Hospitals / Health Care	7,666	Hosp	Schools (Technical/Vocational)	2,187	CC
Industrial - 1 Shift	2,857	Ind	Small Services	3,750	SOfc
Industrial - 2 Shift	4,730	Ind	Sports Arena	1,954	Asy
Industrial - 3 Shift	6,631	Ind	Town Hall	3,748	Asy
Laundromats	4,056	SRet	Transportation	6,456	Asy
Library	3,748	LOfc	Warehouse (Not Refrigerated)	2,602	WH
Light Manufacturers[2]	2,613	Ind	Waste Water Treatment Plant	6,631	Ind
Lodging (Hotels/Motels)	3,064	Hotel/ Motel	Workshop	3,750	Ind
Mall Concourse	4,833	LRet			

[1] New car showrooms and Big Box retail stores with evening and/or weekend hours should use the Facility Type "Retail" for lighting operating hours.
[2] Lighting operating hours data from the 2008 California DEER Update study
[3] Lighting operating hours data for offices used

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

References

1. ECCCNYS 2016, per IECC 2015; Chapter C404.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016: Chapter C404.4: Interior Lighting Power Requirements (Prescriptive) & C405.5: Exterior Lighting Power (Mandatory)
   Available from: https://www1.nyc.gov/site/buildings/codes/2016-energy-conservation-code.page
3. Lighting operating hour data taken from the CL&P and UI Program Savings Documentation for 2008 Program Year, with exceptions as noted.
   Available from:
   https://library.cee1.org/system/files/library/8821/CEE_Eval_2008ProgramSavingsDocumentPSD_1Jan2008.pdf
4. Additional lighting operating hour data taken from 2008 DEER Update – Summary of Measure Energy Analysis Revisions, August, 2008
   Available from: www.deeresources.com
5. Small Business Direct Install Program Evaluation Review, Prepared for the New York State Department of Public Service-E^2 Working Group, by the Small Commercial EM&V Review subcommittee, April 3, 2015
   Available from:
   https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/96006876d01739b785257c85005a58e3/$FILE/ATTGYZRG.pdf/SBDI%20EMV%20studies%20-%20Final%20Report%20-%202015-01-30.pdf

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1	10/15/2010
6-15-4	6/1/2015
1-16-6	12/31/2015
9-17-5	9/30/2017

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REFRIGERATED CASE LED

Measure Description

This measure pertains to installation of horizontally or vertically-mounted LED fixtures in commercial display refrigerators, coolers or freezers. Refrigerated case lighting increases the cooling load of the refrigeration system by adding heat to the unit that must be overcome through additional cooling. Replacing fluorescent lamps with low-heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of waste heat generated from the lamps that must be overcome by the refrigeration system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right) \times hrs \times (1 + (Comp_{eff} \times 0.284))$$

Peak Coincident Demand Savings

$$\Delta kW = \left(\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right) \times CF \times (1 + (Comp_{Eff} \times 0.284))$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electricity energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
W = Rated wattage of lamp or fixture (Watts)
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
1,000 = Conversion factor, one kW equals 1,000 Watts
hrs = Lighting operating hours
CF = Coincidence factor
$Comp_{Eff}$ = Efficiency of the cooler/freezer compressor (kW/Ton)
0.284 = Conversion factor from kW to Tons of refrigeration (Tons/kW)

Summary of Variables and Data Sources

Variable	Value	Notes
$W_{baseline}$		From application, or 2 times the proposed LED wattage[718]
W_{ee}		From application
hrs		From application
$Comp_{Eff}$	Refrigerated Case: 1.00 Freezer Case: 1.92	Typical refrigeration system efficiency (kW/Ton)[719]
CF	0.948	Taken from RLW Analytics, Inc. Coincidence Factor study, "Grocery" facility type

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.948.[720]

Baseline Efficiencies from which Savings are Calculated

The baseline lighting wattage is the rated or deemed wattage of the existing fixture/lamp. See table of standard fixture wattages in Appendix C. If this data is not available, the baseline wattage shall be the proposed wattage multiplied by 2.

Compliance Efficiency from which Incentives are Calculated

The compliance case is a refrigerated display case with horizontally or vertically-mounted LED lighting. Compliance efficiency and fixture/lamp specifications shall be dictated by program eligibility criteria.

Operating Hours

Operating hours for refrigerated case lighting will be site-specific and taken from the application. If unavailable, refer to the "Operating Hours" section of the Commercial and Industrial Interior and Exterior Lamps and Fixtures measure for default hours of operation.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

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718 *REVIEW OF UNDERLYING REFERENCE PENDING:* Based on Pacific Gas & Electric. May 2007. LED Refrigeration Case Lighting Workpaper 053007 rev1. This workpaper is not publicly available, but is referenced by Mid-Atlantic TRM Version 7.0 published May 2017. Assumes LED case lighting (7.6W per linear foot) replacing T8 fluorescent baseline (15.2W per linear foot).

719 Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect average efficiencies of R22 systems.

720 Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures, RLW Analytics, Inc. Spring 2007, Table i-7 (Grocery)

Ancillary Electric Savings Impacts

Reduction in refrigerated case lighting power reduces waste heat that must be displaced by the system. Interactive effects are addressed in the prescribed energy savings calculation methodology.

References

1. Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007.
   Available from:
   https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/116_RLW_CF%20Res%20C&I%20ltg.pdf
2. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-05-2014; EUL ID: GrocDisp-FixtLtg-LED. Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

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0	10/15/2010
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LIGHTING – CONTROL

INTERIOR LIGHTING CONTROL

Measure Description

This section covers lighting control measures, including occupancy sensors, stepped and dimming daylighting controls and programmable control systems, installed on lighting in interior spaces where these controls are not mandated by federal, state or local code. Interior spaces are defined as any covered area not adequately lit during daylight hours by sunlight, thus requiring daytime operation of lighting. These systems save energy and peak demand by shutting off power to lighting fixtures when the space is unoccupied or illumination is not required. They also save energy and demand by reducing power to lighting systems to correct for over-illumination due to excessive lamp output or the presence of daylight.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

ΔkWh	= Annual electricity energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
W_{ctrl}	= Total wattage of controlled lighting (Watts)
1,000	= Conversion factor, one kW equals 1,000 Watts
hrs	= Lighting operating hours
$_{baseline}$	= Baseline condition or measure
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor for peak demand at NYISO coincident summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption (therms/kWh)
ESF	= Energy savings factor
CF	= Coincidence factor

Summary of Variables and Data Sources

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

Energy Savings Factor[721]

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

Control Type	ESF
Occupancy Sensor	0.30
Daylight Dimming Control	0.30
Daylight Stepped Control	0.20
Programmable Control	0.15

- ***Occupancy Sensor*** – Reduces lighting operating hours by switching off lighting in unoccupied spaces.
- ***Daylight Dimming Control*** – Reduces lighting output to a set level in response to natural daylighting using continuous dimming capability.
- ***Daylight Stepped Control*** – Reduces lighting output to a set level in response to natural daylighting using stepped dimming capability.
- ***Programmable Control*** – Sophisticated lighting controllers that combine many of the above functions into a single unit and may also be coupled to the building security system.

[721] *REVIEW OF UNDERLYING REFERENCE PENDING:* ESF values derived from lighting control power adjustment factors prescribed in the California Title 24 Nonresidential Lighting Standards.

Coincidence Factor (CF)

The prescribed coincidence factor for commercial indoor lighting measures is 1.0. [722]

Baseline Efficiencies from which Savings are Calculated

The baseline case for this measure is a lighting system with manual or time-switch controls. This measure is not applicable in spaces for which occupancy or daylight-responsive controls are required by federal, state or local code. Refer to chapter C405.2 Lighting Controls (Mandatory) of the Energy Conservation Construction Code of New York State[723] (ECCCNYS) and the New York City Energy Conservation Code[724] (NYCECC) for details.

Compliance Efficiency from which Incentives are Calculated

The compliance case is a lighting system with occupancy or daylight-responsive controls designed and installed in accordance with manufacturers' and/or designer recommendations. Compliance specifications shall be dictated by program eligibility criteria.

Operating Hours

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

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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

References

1. ECCCNYS 2016, per IECC 2015; Chapter C405.2: Lighting Controls (Mandatory) Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency

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[722] *No source specified – update pending availability and review of applicable references.*
[723] ECCCNYS 2016; C405.2: Lighting Controls (Mandatory)
[724] NYCECC 2016; C405.2: Lighting Controls (Mandatory)

2. NYCECC 2016: Chapter C405.2: Lighting Controls (Mandatory)
Available from: https://www1.nyc.gov/site/buildings/codes/2016-energy-conservation-code.page
3. Energy Savings Factors derived from lighting control power adjustment factors prescribed in the California Title 24 Nonresidential Lighting Standards.
4. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-07-2014; EUL IDs: GlazDayIT-Dayltg, ILtg-OccSens.
Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

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1	10/15/2010
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1-16-7	12/31/2015
9-17-7	9/30/2017

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BI-LEVEL LIGHTING

Measure Description

This measure addresses bi-level occupancy control of lighting in stairwells, corridors, parking garages and parking lots via the installation of controls on existing fixtures or installation of luminaires with integrated bi-level occupancy control. Bi-level occupancy control allows for the continuous lighting of spaces at code-mandated minimum illumination levels when the space is unoccupied and at higher light levels when occupied. This measure is only applicable as a retrofit or replacement in existing buildings because multi-level switching at defined lighting power densities and percentages of full connected load is mandated in many space types by federal, state and local codes and standards, including ECCCNYS 2016[725], NYCECC 2016[726] and ASHRAE 90.1-2013.[727] This measure is restricted to lighting in parking lots and in spaces that are required by fire and safety code to be illuminated continuously. The post-implementation case must comply with all provisions of applicable fire, safety and construction code including but not limited to ECCCNYS 2016[728], NYCECC 2016[729], IBC 2015[730], IPMC 2015[731], NFPA Life Safety Code[732] and NYC Title 27[733].

Method for Calculating Annual Energy Savings and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\frac{W_{baseline}}{1{,}000} - \left(\frac{W_{ee}}{1{,}000} \times (1 - ESF)\right)\right] \times hrs$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left[\frac{W_{baseline}}{1{,}000} - \left(\frac{W_{ee}}{1{,}000} \times (1 - DSF)\right)\right] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of fixtures equipped with bi-level occupancy control under the program

[725] ECCCNYS 2016, Section C405
[726] NYCECC 2016, Section C405
[727] ASHRAE 90.1-2013, Section 9
[728] ECCCNYS 2016, Chapter 4
[729] NYCECC 2016, Chapter 4
[730] International Building Code 2015 (3rd Printing as adopted by New York State)
[731] International Property Maintenance Code 2015 (4th Printing as adopted by New York State)
[732] National Fire Protection Association, Life Safety Code, 2018 Edition
[733] NYC Administrative Code, Title 27, Construction and Maintenance, Chapter 1. Building Code

$W_{baseline}$ = Wattage of the existing fixture
W_{ee} = Wattage of the efficient fixture at full light output
ESF = Energy Savings Factor
DSF = Demand Savings Factor
hrs = Annual operating hours
CF = Coincidence Factor
1,000 = Conversion factor, one kW equals 1,000 watts

Summary of Variables and Data Source

Variable	Value	Notes
$W_{baseline}$		From application.
W_{ee}		From application. If bi-level occupancy controls are installed on existing fixtures, $W_{ee} = W_{baseline}$.
ESF		See Energy Savings Factor section below.
hrs	Parking Lots: 4,380 Interior: 8,760	Parking lot lighting is assumed to operate 12 hours per day. For interior spaces, this measure is restricted to those illuminated year-round.
DSF	Parking Garage: ESF Other: 0	DSF shall be set equal to the computed ESF value for parking garages. For all other space types, set DSF equal to 0.
CF	Parking Lots: 0.0 Interior: 1.0	

Energy Savings Factor

The energy savings factor represents the average annual percent reduction in wattage, as compared with the full light output wattage of the efficient case, resulting from bi-level occupancy control capability. The ESF is established based on the low-power mode wattage of the efficient case and assumed occupied hours of the affected space as follows:

$$ESF = F_{low} \times \left(1 - \frac{W_{low}}{W_{ee}}\right)$$

where:

F_{low} = Low-power mode factor; represents the percent of annual operating hours that the fixture operates in low-power mode.
W_{low} = Wattage of the efficient fixture in low-power mode
W_{ee} = Wattage of the efficient fixture at full light output

F_{low}, W_{low} and W_{ee} shall be taken from the application. If unknown, look up F_{low} default values from the table below, based on space type.

Space Type	F_{low}
Stairwell[734]	0.73
Corridor[735]	0.75
Parking Garage[736]	0.56
Parking Lot[737]	0.45

Coincidence Factor (CF)

The methodology and default values used in this measure assume continuous operation of lighting in affected interior spaces. Therefore, the prescribed value for the coincidence factor for interior spaces is 1.0. Since exterior lighting typically does not operate during daylight hours, the prescribed value for the coincidence factor for parking lots is 0.0.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is lighting in interior spaces required to be illuminated year-round and lighting in parking lots automatically controlled by photocells or time clocks.

Compliance Efficiency from which Savings are Calculated

The compliance condition is lighting in interior spaces required to be illuminated year-round and parking lots with bi-level occupancy control installed and meeting all provisions of applicable federal, state and local fire, safety and construction code.

Operating Hours

This measure is restricted to lighting in interior spaces required to be illuminated year-round and parking lots, assumed to operate 12 hours per day. The annual operating hours for these spaces are 8,760 and 4,380, respectively. Typical occupancy assumptions used to derive F_{low} values are as noted in the Energy Savings Factor section above.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction in lighting hours reduces space cooling and increases space heating requirements in conditioned spaces. Interactive HVAC impacts are not included in this methodology.

[734] California Energy Commission, Lighting Research Program, Project 5.1 Bi-level Stairwell Fixture Performance Final Report, October 2005 – Average of "Time Dimmed" across the four test sites during weekday operation (Table 2. Weekday daily average energy usage and savings, pg. 22)
[735] CA State Partnership for Energy Efficiency Demonstrations, Interior Lighting Case Study: Adaptive Corridor Lighting, April 2014, pg. 2
[736] California Energy Commission Public Interest Energy Research Program, Case Study: Bi-Level LED Parking Garage Luminaires – Average of unoccupied hours across the three test sites
[737] Pacific Gas & Electric, Application Assessment of Bi-Level LED Parking Lot Lighting, February 2009, pg. 1

Ancillary Electric Savings Impacts

Reduction in lighting hours reduces space cooling and increases space heating requirements in conditioned spaces. Interactive HVAC impacts are not included in this methodology.

References

1. ECCCNYS 2016, per IECC 2015, Chapter 4 Commercial Energy Efficiency
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
2. NYCECC 2016, Chapter 4 Commercial Energy Efficiency
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
3. ANSI/ASHRAE/IES Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings, Section 9. Lighting
4. International Building Code 2015 (3rd Printing as adopted by New York State)
   Available from: https://codes.iccsafe.org/public/document/toc/1059/
5. International Property Maintenance Code 2015 (4th Printing as adopted by New York State)
   Available from: https://codes.iccsafe.org/public/document/toc/1052/
6. National Fire Protection Association, Life Safety Code, 2018 Edition
   Available from: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=101
7. NYC Administrative Code, Title 27, Construction and Maintenance, Chapter 1. Building Code
   Available from: http://ny.elaws.us/law/adc_t27_ch1
8. California Energy Commission, Lighting Research Program, Project 5.1 Bi-level Stairwell Fixture Performance Final Report, October 2005
   Available from: http://www.energy.ca.gov/2005publications/CEC-500-2005-141/CEC-500-2005-141-A16.PDF
9. CA State Partnership for Energy Efficiency Demonstrations, Interior Lighting Case Study: Adaptive Corridor Lighting, April 2014
   Available from:
   http://cltc.ucdavis.edu/sites/default/files/files/publication/CASE_STUDY_UCSF_Adaptive_Corridors_140602.pdf
10. California Energy Commission Public Interest Energy Research Program, Case Study: Bi-Level LED Parking Garage Luminaires
    Available from: http://cltc.ucdavis.edu/sites/default/files/files/publication/case-study-bi-level-led-garage-luminaires.pdf
11. Pacific Gas & Electric, Application Assessment of Bi-Level LED Parking Lot Lighting, February 2009
    Available from: https://www.creelink.com/exLink.asp?13226928OH86Q71I31038612

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1-16-11	12/31/2015
9-18-14	9/28/2018

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MOTORS AND DRIVES

MOTOR REPLACEMENT

Measure Description

This measure covers the installation of high efficiency, three-phase electric HVAC fan or pump motors of 200 hp or less in commercial and industrial applications.[738] Full-load efficiency of installed equipment must exceed current code requirements as defined in the Baseline Efficiency section below to qualify. Estimated energy savings are based on increased operating efficiency.

Efficient motors generally run at slightly higher RPM than standard motors. Unless the motor drive system is modified to correct for higher RPM operation, the power delivered by the motor may increase. This increase in power delivery may negate the effects of improved efficiency. Therefore, when replacing a standard-efficiency motor, a high-efficiency motor with lower or equal full-load speed must be selected to prevent any negation of predicted energy savings resulting from a higher efficiency. To provide the correct flow, it may be necessary to adjust fan sheaves or pump-impeller diameters.[739]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times hp \times RLF \times 0.746\ (kW/hp) \times \left[\left(\frac{1}{Eff_{baseline}}\right) - \left(\frac{1}{Eff_{ee}}\right)\right] \times FLH$$

Peak Coincident Demand Savings

$$\Delta kW = units \times hp \times RLF \times 0.746\ (kW/hp) \times \left[\left(\frac{1}{Eff_{baseline}}\right) - \left(\frac{1}{Eff_{ee}}\right)\right] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
hp	= Horsepower
RLF	= Rated load factor
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure

[738] Partners Listing of NEMA Premium Compliant Electric Motors (accessed 3/19/2018)
[739] Energy Innovators Initiative, Office of Energy Efficiency, Natural Resources Canada, Premium-Efficiency Motors

Eff = Energy efficiency (0 -100%)
FLH = Full-load hours
CF = Coincidence factor
0.746 = Conversion factor (kW/hp), 746 watts equals one horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		Rated horsepower of the efficient equipment, from application.
$Eff_{baseline}$		Full-load efficiency of the baseline motor. Look up from Appendix L based on efficient motor type (open or enclosed), number of poles (2, 4 or 6) and horsepower.
Eff_{ee}		Full-load efficiency of the efficient motor, from application.
RLF		Ratio of the peak annual motor load to the maximum connected load (RLF = hp_{peak}/hp_{max}), from application. If unknown, assume 0.75.[740]
FLH		Full-load hours in the energy efficient case, from application. If unknown, look up based on facility type and motor application in the Operating Hours section below.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8.[741]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a three-phase electric HVAC fan or pump motor of equivalent type, speed and horsepower to the efficient case with minimally code compliant full-load efficiency per Appendix L, established by ECCCNYS[742] and NYCECC,[743] in accordance with federal energy conservation standards.[744]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a three-phase electric HVAC fan or pump motor with a speed at or below that of the baseline motor and full-load efficiency exceeding the baseline NEMA premium full-load efficiency established per the Baseline Efficiencies section above.

Operating Hours

Motor full-load hours are defined as the total annual energy consumption divided by the peak

[740] U.S. DOE, Determining Electric Motor Load and Efficiency, p. 1; assumes system is designed to maximize efficiency.
[741] *No source specified – update pending availability and review of applicable references.*
[742] ECCCNYS 2016, Table C405.8(1)
[743] NYCECC 2016, Table C405.8(1)
[744] 10 CFR 431.25(h) Table 5

hourly demand.

$$FLH = \frac{kWh}{kW_{max}}$$

For loads that do not vary with time (i.e., a motor driving a constant load), full-load hours are equal to the operating hours.

If full-load hours are unknown, use default values based on the application and building type from the table below.[745]

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Auto Related	4,056	1,878	5,376
Bakery	2,854	1,445	5,376
Banks, Financial Centers	3,748	1,767	5,376
Church	1,955	1,121	5,376
College - Cafeteria	6,376	2,713	5,376
College - Classes/Administrative	2,586	1,348	5,376
College - Dormitory	3,066	1,521	5,376
Commercial Condos	4,055	1,877	5,376
Convenience Stores	6,376	2,713	5,376
Convention Center	1,954	1,121	5,376
Court House	3,748	1,767	5,376
Dining: Bar Lounge/Leisure	4,182	1,923	5,376
Dining: Cafeteria / Fast Food	6,456	2,742	5,376
Dining: Family	4,182	1,923	5,376
Entertainment	1,952	1,120	5,376
Exercise Center	5,836	2,518	5,376
Fast Food Restaurants	6,376	2,713	5,376
Fire Station (Unmanned)	1,953	1,121	5,376
Food Stores	4,055	1,877	5,376
Gymnasium	2,586	1,348	5,376
Hospitals	7,674	3,180	5,376
Hospitals / Health Care	7,666	3,177	5,376
Industrial - 1 Shift	2,857	1,446	5,376
Industrial - 2 Shift	4,730	2,120	5,376
Industrial - 3 Shift	6,631	2,805	5,376
Laundromats	4,056	1,878	5,376
Library	3,748	1,767	5,376
Light Manufacturers	2,857	1,446	5,376
Lodging (Hotels/Motels)	3,064	1,521	5,376

[745] Connecticut Program Savings Document, 12th Edition for 2017 Program Year, UIL Holdings Corporation and Eversource Energy, October 2016. Appendix 5, Hours of Use

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Mall Concourse	4,833	2,157	5,376
Manufacturing Facility	2,857	1,446	5,376
Medical Offices	3,748	1,767	5,376
Motion Picture Theatre	1,954	1,121	5,376
Multi-Family (Common Areas)	7,665	3,177	5,376
Museum	3,748	1,767	5,376
Nursing Homes	5,840	2,520	5,376
Office (General Office Types)	3,748	1,767	5,376
Office/Retail	3,748	1,767	5,376
Parking Garages & Lots	4,368	1,990	5,376
Penitentiary	5,477	2,389	5,376
Performing Arts Theatre	2,586	1,348	5,376
Police / Fire Stations (24 Hr)	7,665	3,177	5,376
Post Office	3,748	1,767	5,376
Pump Stations	1,949	1,119	5,376
Refrigerated Warehouse	2,602	1,354	5,376
Religious Building	1,955	1,121	5,376
Residential (Except Nursing Homes)	3,066	1,521	5,376
Restaurants	4,182	1,923	5,376
Retail	4,057	1,878	5,376
School / University	2,187	1,205	5,376
Small Services	3,750	1,768	5,376
Sports Arena	1,954	1,121	5,376
Town Hall	3,748	1,767	5,376
Transportation	6,456	2,742	5,376
Warehouse (Not Refrigerated)	2,602	1,354	5,376
Waste Water Treatment Plant	6,631	2,805	5,376
Workshop	3,750	1,768	5,376

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

High efficiency motors reject less heat into the conditioned space increasing space heating requirements while decreasing cooling load. These impacts are not considered in the prescribed formulation of savings.

Ancillary Electric Savings Impacts

High efficiency motors reject less heat into the conditioned space increasing space heating requirements while decreasing cooling load. These impacts are not considered in the prescribed formulation of savings.

References

1. Partners Listing of NEMA Premium Compliant Electric Motors
   Available from:
   https://www.nema.org/Policy/Energy/Efficiency/Documents/Nema_Premium_Partners.pdf
2. Energy Innovators Initiative, Office of Energy Efficiency, Natural Resources Canada, Premium-Efficiency Motors
   Available from: https://www.prismengineering.com/sites/default/files/upload/fact-sheets/Prism-Fact-sheet-Premium-efficiency-motors.pdf
3. U.S. DOE, Determining Electric Motor Load and Efficiency
   Available from: https://energy.gov/sites/prod/files/2014/04/f15/10097517.pdf
4. ECCCNYS 2016, per IECC 2015; Table C405.8(1): Minimum Nominal Full-Load Efficiency For 60 HZ NEMA General Purpose Electric Motors (Subtype I) Rated 600 Volts or Less
   Available from: https://codes.iccsafe.org/public/document/IECC2015NY-1/chapter-4-ce-commercial-energy-efficiency
5. NYCECC 2016, per IECC 2015; Table C405.8(1): Minimum Nominal Full-Load Efficiency For 60 HZ NEMA General Purpose Electric Motors (Subtype I) Rated 600 Volts or Less
   Available from:
   https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016ECC_CHC4.pdf&section=energy_code_2016
6. 10 CFR 431.25 (h) Table 5: Nominal Full-Load Efficiencies of NEMA Design A, NEMA Design B and IEC Design N Motors (Excluding Fire Pump Electric Motors) at 60Hz
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=5423daf354376cde95da84156e424cc8&mc=true&node=pt10.3.431&rgn=div5#sp10.3.431.b
7. Connecticut Program Savings Document, 12th Edition for 2017 Program Year, UIL Holdings Corporation and Eversource Energy, October 2016

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-18-12	6/26/2018

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VARIABLE FREQUENCY DRIVE – FAN AND PUMP

Measure Description

This measure addresses variable frequency drives applied to fans and pumps in commercial and industrial buildings. Applications covered in this section are; AHU supply and return fans, CHW pumps, cooling tower fans, condenser water pumps and heating hot water pumps.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = units \times hp \times (\Delta kW/hp) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
hp = Horsepower
(ΔkWh/hp) = Annual electric energy savings (in kWh) per controlled motor horsepower
(ΔkW/hp) = Electric demand savings (in kW) per controlled motor horsepower
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
hp		Horsepower rating of motor controlled by VFD, from application
(ΔkW/hp)		Electric demand savings from VFD per horsepower of motor controlled. Lookup in Appendix K by building type and VFD application. If no deemed savings are specified, (ΔkW/hp) = 0.
(ΔkWh/hp)		Annual energy savings from VFD per horsepower of motor controlled. Lookup in Appendix K by building type, city and VFD application.
CF	0.8	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 0.8. [746]

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

Baseline Efficiencies from which Savings are Calculated

The baseline system characteristics by application are as follows:

- Chilled water and hot water pumps:
    - Variable volume, constant speed secondary pumping system
        - Existing pump rides pump curve as flow varies
- Supply fans:
    - VAV system with inlet vane control
- Return fans:
    - VAV system with discharge damper control
- Cooling tower fans:
    - One speed constant volume fan
- Condenser water pumps:
    - Constant speed, constant flow condenser water pumps

Compliance Efficiency from which Incentives are Calculated

The compliance system characteristics by application are as follows:

- Chilled water and hot water pumps:
    - Variable volume, variable speed secondary pumping system
- Supply fans:
    - VAV system with VFD control
- Return fans:
    - VAV system with VFD control
- Cooling tower fans:
    - Variable speed fans controlling condenser water temperature to 85°F
- Condenser water pumps:
    - Variable speed, variable flow condenser water loop

Operating Hours

The annual energy savings from VFD per horsepower of motor controlled (ΔkWh/hp) defined in Appendix K incorporate operating hours consideration.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

1. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-07-2014; EUL IDs: HVAC-VSD-fan and HVAC-VSDSupFan.
   Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-12	7/31/2013
9-17-8	9/30/2017

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PROCESS EQUIPMENT

STEAM TRAP REPAIR OR REPLACEMENT – OTHER APPLICATIONS

Measure Description

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

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

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

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

$$P_a = psig + psia$$

where:

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

Summary of Variables and Data Sources

Variable	Value	Notes
$Loss_{steam}$		Calculated per the equation above, dependent upon system operating pressure (psig) and steam trap orifice diameter (Dia).
Dia		From application.
P_a		Calculated per the equation above, dependent upon system operating pressure (psig).
Psig		From application.
Psia		Atmospheric pressure (14.7 psi) where system is vented and not a pressurized or vacuum condensate return system; otherwise, psia should be established such that P_a reflects the pressure differential across the steam trap.
F_{derate}	0.32	Public Service Commission of Wisconsin. [747]
ΔH_{vap}		Look up from table below based on system operating pressure (psig).
Eff		Boiler efficiency, from application. Either E_t or AFUE shall be used, based on nameplate rating metric of existing equipment or actual system efficiency as provided on the application and documented by the customer.
hrs		From application. If unknown, use a default of 8,424 for industrial applications[748] and 2,425 for dry cleaners.[749]

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

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

[749] CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012. The CLEAResults Work Paper is not publicly available, but is referenced by the Illinois TRM Version 6, pg 214

Heat of Vaporization (BTU/lb)[750]

Absolute Pressure (Pa)	Heat of Vaporization (BTU/lb)	Absolute Pressure (Pa)	Heat of Vaporization (BTU/lb)	Absolute Pressure (Pa)	Heat of Vaporization (BTU/lb)
0	1,052.1	**70**	908.1	**500**	755.5
1	1,035.7	**75**	904.6	**550**	743.5
2	1,021.8	**80**	901.2	**600**	732.1
3	1,012.8	**85**	898.0	**700**	710.2
4	1,006.0	**90**	894.9	**800**	689.4
5	1,000.5	**95**	891.9	**900**	669.4
6	995.9	**100**	889.0	**1,000**	649.9
7	991.8	**110**	883.4	**1,100**	631.0
8	988.1	**120**	878.2	**1,200**	312.3
9	984.8	**130**	873.2	**1,300**	593.9
10	981.9	**140**	868.5	**1,400**	575.5
15	969.5	**150**	863.9	**1,500**	557.3
20	959.9	**160**	859.5	**1,600**	539.1
25	952.0	**170**	855.2	**1,700**	520.8
30	945.2	**180**	851.2	**1,800**	502.3
35	939.2	**190**	847.2	**1,900**	483.6
40	933.7	**200**	843.3	**2,000**	464.6
45	928.7	**250**	825.5	**2,250**	415.1
50	924.0	**300**	809.4	**2,500**	360.8
55	919.7	**350**	794.6	**2,750**	297.8
60	915.6	**400**	780.9	**3,000**	214.4
65	911.8	**450**	767.8		

Coincidence Factor (CF)

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

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

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

[750] Values in this table were calculated from NIST Standard Reference Database 10, "NIST/ASME Steam Properties," Ver. 2.11, National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, 1997

Operating Hours

Operating hours of steam trap system are assumed to be 8,424[751] for industrial and process applications and 2,425[752] for steam traps used in dry cleaners.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

N/A

References

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

Record of Revision

Record of Revision Number	Issue Date
9-18-17	9/28/2018

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[751] Assumes constant operation except for 2 weeks out of the year when boilers are often shutoff for maintenance
[752] CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012, Work Paper not publicly available, but reported in Illinois TRM Version 6, pg 214

REFRIGERATION

AIR-COOLED REFRIGERATION CONDENSER

Measure Description

This measure covers the installation of efficient, close approach remote air-cooled refrigeration system condensers typically found in supermarkets. An approach temperature of 8°F or less for low temperature systems and 13°F for medium temperature systems is required. Additionally, condenser efficiency must be greater than or equal to 85 BTU/h of heat rejection capacity per watt of fan power. Savings are derived from the reduction in condensing temperatures and improved efficiency of the condenser fan system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times (\Delta kW/ton) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
tons/unit = Tons of refrigeration per unit, based on compressor nameplate
(ΔkWh/ton) = Annual electric energy savings per ton of compressor capacity
(ΔkW/ton) = Electric demand savings per ton of compressor capacity
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		From application.
(ΔkWh/ton)		Look up based on city from Energy and Demand Savings table below.
(ΔkW/ton)		Look up based on city from Energy and Demand Savings table below.
CF	1.0	

Energy and Demand Savings

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a prototypical grocery store. The prototype building characteristics are described in Appendix A. The unit energy and demand savings for seven different cities in NY are shown below.

City	(ΔkWh/ton)	(ΔkW/ton)
Albany	1,296	0.136
Binghamton	1,290	0.143
Buffalo	1,297	0.103
Massena	1,301	0.123
NYC	1,220	0.152
Poughkeepsie	1,258	0.144
Syracuse	1,283	0.149

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[753]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be a standard efficiency air-cooled refrigeration system condenser, with a 15ºF approach temperature on low temperature applications and a 20ºF approach temperature on medium temperature applications. The baseline condition assumes a standard efficiency of 45 BTU/h of heat rejection capacity per watt of fan power.[754]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is an efficient air-cooled refrigeration system condenser, with an approach temperature of 8ºF or less on low temperature applications and an approach temperature of 13ºF or less on medium temperature applications. Condenser efficiency must be greater than or equal to 85 BTU/h of heat rejection capacity per watt of fan power. [755]

Operating Hours

Refrigeration equipment is assumed to be available for operation 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

[753] *No source specified – update pending availability and review of applicable references.*
[754] DEER Update Study, Final Report, December 2005. p. 7-69
[755] DEER Update Study, Final Report, December 2005. p. 7-69

Ancillary Electric Savings Impacts

N/A

References

1. California DEER, 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005
Available from: www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Record of Revision

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1	10/15/2010
3-18-15	3/29/2018

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EVAPORATOR FAN MOTOR – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR, FOR REFRIGERATED CASE OR WALK-IN COOLER/FREEZER

Measure Description

This measure covers replacement of single-phase shaded pole (SP) or permanent split capacitor (PSC) evaporator fan motors with electronically commutated (EC) motors in walk-in and reach-in refrigerated cases. These high-efficiency motors achieve savings by reducing evaporator fan power and through interactive effects with the system's compressor. EC motors introduce less waste heat into the refrigerated case, reducing the total refrigeration load. This measure is only applicable in a 1:1 replacement of existing, single-phase SP or PSC motor output. This measure applies to equipment manufactured before January 1, 2009 only, as the Code of Federal Regulations requires the use of EC or three-phase motors in evaporator fans in equipment manufactured on or after that date.[756]

Method for Calculating Annual Energy and Peak Coincident Demand Savings for Walk-In Coolers/Freezers

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{EFan} + \Delta kWh_{RH}$$

$$\Delta kWh_{EFan} = units \times \left(\frac{A_{EFan} \times V_{EFan} \times \sqrt{Phase_{EFan}}}{1{,}000}\right) \times F_{PA} \times F_{EFan} \times hrs_{EFan}$$

$$\Delta kWh_{RH} = \Delta kWh_{EFan} \times Comp_{Eff} \times 0.284$$

Peak Coincident Demand Savings

$$\Delta kW = \Delta kW_{EFan} + \Delta kW_{RH}$$

$$\Delta kW_{EFan} = units \times \left(\frac{A_{EFan} \times V_{EFan} \times \sqrt{Phase_{EFan}}}{1{,}000}\right) \times F_{PA} \times F_{EFan} \times CF$$

$$\Delta kW_{RH} = \Delta kW_{EFan} \times Comp_{Eff} \times 0.284$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
ΔkWh_{EFan}	= Annual electric savings due to evaporator fan motor replacement

[756] 10 CFR 431.306

ΔkWh_{RH} = Annual electric savings due to reduced heat from evaporator fan motor replacement
ΔkW_{EFan} = Peak coincident demand savings due to evaporator fan motor replacement
ΔkW_{RH} = Peak coincident demand savings due to reduced heat from evaporator fan motor replacement
units = Number of measures installed under the program
A_{EFan} = Nameplate amperage of existing evaporator fan motor
V_{EFan} = Nameplate voltage of existing evaporator fan motor
$Phase_{EFan}$ = Phase of existing evaporator fan
1,000 = Conversion factor, one kW equals 1,000 W
F_{PA} = Power factor
F_{EFan} = Reduction of load by replacing evaporator fan motor
hrs_{EFan} = Evaporator fan annual operating hours
$Comp_{Eff}$ = Efficiency of the cooler/freezer compressor (kW/Ton)
0.284 = Conversion factor from kW to Tons of refrigeration (Tons/kW)
CF = Coincidence factor

Method for Calculating Annual Energy and Peak Coincident Demand Savings for Refrigerated Cases

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{CM} + \Delta kWh_{RH}$$

$$\Delta kWh_{CM} = units \times \left(\frac{A_{EFan} \times V_{EFan} \times \sqrt{Phase_{EFan}}}{1{,}000}\right) \times F_{PA} \times F_{CM} \times hrs_{CM}$$

$$\Delta kWh_{RH} = \Delta kWh_{CM} \times Comp_{Eff} \times 0.284$$

Peak Coincident Demand Savings

$$\Delta kW = \Delta kW_{CM} + \Delta kW_{RH}$$

$$\Delta kW_{CM} = units \times \left(\frac{A_{EFan} \times V_{EFan} \times \sqrt{Phase_{EFan}}}{1{,}000}\right) \times F_{PA} \times F_{CM} \times CF$$

$$\Delta kW_{RH} = \Delta kW_{CM} \times Comp_{Eff} \times 0.284$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
$\Delta therms$	= Annual gas energy savings
ΔkWh_{CM}	= Annual electric savings due to case motor replacement
ΔkWh_{RH}	= Annual electric savings due to reduced heat from case motor replacement
ΔkW_{CM}	= Peak coincident demand savings due to case motor replacement
ΔkW_{RH}	= Peak coincident demand savings due to reduced heat from case motor replacement
units	= Number of measures installed under the program
A_{EFan}	= Nameplate amperage of existing evaporator fan motor
V_{EFan}	= Nameplate voltage of existing evaporator fan motor
$Phase_{EFan}$	= Phase of existing evaporator fan
F_{PA}	= Power adjustment factor
F_{CM}	= Reduction of load by replacing case motor
hrs_{CM}	= Case motor annual operating hours
$Comp_{Eff}$	= Efficiency of the cooler/freezer compressor (kW/Ton)
1,000	= Conversion factor, one kW equals 1,000 W
0.284	= Conversion factor from kW to Tons of refrigeration (Tons/kW)
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
A_{EFan}		From application
V_{EFan}		From application
$Phase_{EFan}$		From application
F_{PA}	0.55	Based on experience of National Resource Management (NRM) [757]
hrs_{EFan}	Cooler Control: 5,600 No Cooler Control: 8,760	Based on experience of NRM[758]
hrs_{CM}	8,500	Based on experience of NRM[759]
F_{EFan}	0.65	Based on numerous pre and post meter readings conducted by NRM and supported by RLW Analytics evaluation.[760]
F_{CM}	Shaded Pole: 0.53 PSC: 0.29	If a shaded pole motor is being replaced, use 0.53. If a PSC motor is being replaced, use 0.29. Based on numerous pre and post meter readings conducted by NRM.[761]

[757] *REVIEW OF UNDERLYING REFERENCE PENDING:* Cooler Control Measure Impact Spreadsheet User's Manual, Select Energy Services, Inc., March 2004
[758] Ibid.
[759] Ibid.
[760] Small Business Services, Custom Measure Impact Evaluation, RLW Analytics, Inc., March 2007.
[761] *REVIEW OF UNDERLYING REFERENCE PENDING:* Cooler Control Measure Impact Spreadsheet User's Manual, Select Energy Services, Inc., March 2004

Variable	Value	Notes
$Comp_{Eff}$	Cooler: 1.00 Freezer: 1.92	Typical refrigeration system efficiency (kW/Ton)[762]
CF	1.0	

Coincidence Factor (CF)

The prescribed value for the coincidence factor is 1.0.[763]

Baseline Efficiencies from which Savings are Calculated

The baseline case is a walk-in cooler/freezer or refrigerated display case with shaded pole or permanent split capacitor (PSC) evaporator fan motors.

Compliance Efficiency from which Incentives are Calculated

The compliance case is a walk-in cooler/freezer or refrigerated display case with electronically commutated (EC) evaporator fan motors with full load efficiency exceeding that prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 and/or 10 CFR 431.25 as applicable.

Operating Hours

The annual operating hours of a walk-in cooler or freezer evaporator fan motor is 8,760 when a cooler control system is not a component of the efficient system and 5,600 otherwise. The annual operating hours for a refrigerated display case motor are 8,500.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

Ancillary Electric Savings Impacts

Reduction in evaporator fan power reduces waste heat that must be displaced by the compressor. Interactive effects are addressed in the prescribed energy savings calculation methodology.

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762 Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect average efficiencies of systems using R-22, which was the most common refrigerant in active refrigeration systems in 2008 (per Analysis of Equipment and Practices in the Reclamation Industry, October 2010). Because this methodology applies to existing equipment manufactured prior to January 1, 2009, 2008 data is considered most pertinent for the purposes of this measure.

763 *No source specified – update pending availability and review of applicable references.*

References

1. *Cooler Control Measure Impact Spreadsheet Users' Manual*, Select Energy Services, Inc. for NSTAR, March 9, 2004
2. Small Business Services, Custom Measure Impact Evaluation, RLW Analytics, Inc. for National Grid, March 23, 2007
   Available from: https://library.cee1.org/system/files/library/8713/CEE_Eval_2007CustomMeasureImpactEvaluation_23Mar2007.pdf
3. 10 CFR 431.306 Energy conservations standards and their effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=bf918c7935d524eeb5d031252bb66fba&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1306
4. Analysis of Equipment and Practices in the Reclamation Industry
   Available from: https://www.epa.gov/sites/production/files/2015-08/documents/analysis_of_equipment_and_practices_in_the_reclamation_industry.pdf
5. 10 CFR 431.446 Small electric motors energy conservation standards and their effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=f7f8d64bb400ae3dc2d13f131cf116bb&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_1446
6. 10 CFR 431.25 Energy conservation standards and effective dates
   Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=070fc8cd95943842a1e7a6f793d73496&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_125

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-17	7/31/2013
9-17-9	9/30/2017
9-18-15	9/28/2018

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Refrigerated Case Night Cover

Measure Description

This measure covers the installation of retractable curtains on open horizontal or multi-deck refrigerated display cases in grocery stores. These covers serve as a barrier between the contents of the refrigerated case and the ambient air during off-business hours. They conserve energy by reducing the infiltration of ambient air into the refrigerated space, thereby reducing the load on the refrigeration system. Grocery stores operating 24 hours per day are not eligible for energy savings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times TDEC \times ESF \times 365$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of display cases addressed by the program
TDEC = Total Daily Energy Consumption (kWh/day)
ESF = Energy savings factor
365 = Days in one year

Summary of Variables and Data Sources

Variable	Value	Notes
TDEC		Total Daily Energy Consumption (kWh/day), calculate based on Total Display Area (TDA) from table below
ESF	0.09	Energy savings factor associated with installation of refrigerated case night covers[764]

Coincidence Factor (CF)

Energy savings associated with installation of refrigerated case night covers occur during off-peak hours, so no coincident peak demand savings are deemed for this measure.

[764] Southern California Edison, Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, August 1997

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a vertical or horizontal open refrigerated display case left uncovered during off-business hours and meeting the minimum federal energy standards presented in the tables below.[765] Equipment with an operating temperature above 32°F is classified as Medium with a rating temperature of 38°F, while equipment with an operating temperature of 32°F or below is classified as Low with a rating temperature of 0°F. Ice Cream freezers have a rating temperature of -15°F and operate at temperatures below -5°F.

Total Daily Energy Consumption (TDEC) shall be calculated per the table below for the appropriate display case type, configuration and rating temperature. For refrigeration equipment with two or more compartments (i.e. hybrid refrigerators, freezers, refrigerator-freezers and non-hybrid refrigerator freezers), the TDEC shall be established as the sum of the TDEC values associated with each component compartment. Total Display Area (TDA), if unspecified by the manufacturer, should be calculated as:

$$TDA = l \times Ht$$

where:

TDA = Total display area of the open case (ft^2)
l = Length of the display case opening (ft)
Ht = Height (vertical) or Depth (horizontal) of the display case opening (ft)

Baseline Efficiencies for Refrigerators, Freezers, or Refrigerator-freezers manufactured on or after March 27, 2017

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Medium (38°F)	0.64 x TDA + 4.07
Vertical Open	Remote Condensing	Low (0°F)	2.20 x TDA + 6.85
Vertical Open	Remote Condensing	Ice Cream (-15°F)	2.79 x TDA + 8.70
Vertical Open	Self-Contained	Medium (38°F)	1.69 x TDA + 4.71
Vertical Open	Self-Contained	Low (0°F)	4.25 x TDA + 11.82
Vertical Open	Self-Contained	Ice Cream (-15°F)	5.40 x TDA + 15.02
Horizontal Open	Remote Condensing	Medium (38°F)	0.35 x TDA + 2.88
Horizontal Open	Remote Condensing	Low (0°F)	0.55 x TDA + 6.88
Horizontal Open	Remote Condensing	Ice Cream (-15°F)	0.70 x TDA + 8.74
Horizontal Open	Self-Contained	Medium (38°F)	0.72 x TDA + 5.55
Horizontal Open	Self-Contained	Low (0°F)	1.90 x TDA + 7.08
Horizontal Open	Self-Contained	Ice Cream (-15°F)	2.42 x TDA + 9.00

Baseline Efficiencies for Refrigerators, Freezers, and Refrigerator-freezers manufactured before March 27, 2017

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Medium (38°F)	0.82 × TDA + 4.07

765 10 CFR 431.66(e)(1)

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Low (0°F)	2.27 × TDA + 6.85
Vertical Open	Remote Condensing	Ice Cream (-15°F)	2.89 × TDA + 8.70
Vertical Open	Self-Contained	Medium (38°F)	1.74 × TDA + 4.71
Vertical Open	Self-Contained	Low (0°F)	4.37 × TDA + 11.82
Vertical Open	Self-Contained	Ice Cream (-15°F)	5.55 × TDA + 15.02
Horizontal Open	Remote Condensing	Medium (38°F)	0.35 × TDA + 2.88
Horizontal Open	Remote Condensing	Low (0°F)	0.57 × TDA + 6.88
Horizontal Open	Remote Condensing	Ice Cream (-15°F)	2.44 × TDA + 9.00
Horizontal Open	Self-Contained	Medium (38°F)	0.77 × TDA + 5.55
Horizontal Open	Self-Contained	Low (0°F)	1.92 × TDA + 7.08
Horizontal Open	Self-Contained	Ice Cream (-15°F)	2.44 × TDA + 9.00

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a vertical or horizontal open refrigerated display case with retractable night covers installed.

Operating Hours

Energy savings are based on installation of refrigerated case night covers in an 18-hour[766] supermarket assumed to operate 365 days per year. Therefore, the annual hours that night covers are assumed to be in use are (24 – 18) x 365 = 2,190 hours.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction in heat transfer between the refrigerated case and the ambient air will result in a small reduction in space heating requirements. This impact is negligible and occurs only during unoccupied hours, so is not considered in this methodology.

Ancillary Electric Savings Impacts

Reduction in heat transfer between the refrigerated case and the ambient air will result in a small reduction in space heating requirements and a small increase in cooling requirements. This impact is negligible and occurs only during unoccupied hours, so is not considered in this methodology.

References

1. Southern California Edison, Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, August 1997

[766] Southern California Edison, Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, August 1997

Available from: http://www.econofrost.com/acrobat/sce_report_long.pdf
2. 10 CFR 431.66 Energy conservation standards and their effective dates.
Available from: https://www.ecfr.gov/cgi-bin/text-idx?SID=991ee62d32fb598ccb945f43a316ff32&mc=true&node=pt10.3.431&rgn=div5#se10.3.431_166

Record of Revision

Record of Revision Number	**Issue Date**
1	10/15/2010
3-18-4	3/29/2018

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FREEZER AND COOLER DOOR STRIP

Measure Description

This measure covers the repair or replacement of existing damaged or missing strip curtains on walk-in freezers and coolers with a chilled storage area of less than 3,000ft^2.[767] Strip curtains on both walk-in freezers (≤ 32°F) and walk-in coolers (> 32°F and ≤ 55°F) serve to prevent air infiltration during periods when the main door is open for routine stocking activity. When damaged or missing, the warmer, more humid air present in the store will infiltrate the unit, increasing the load of the refrigeration system and often reducing the efficiency of the evaporator unit as frost accumulates, impairing its effectiveness. This measure applies to strip curtains on the main door of walk-in units typical of supermarkets, convenience stores and restaurants.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = {ft^2}_{door} \times (\Delta kWh/ft^2)_{door}$$

Peak Coincident Demand Savings

$$\Delta kW = {ft^2}_{door} \times \frac{(\Delta kWh/ft^2)_{door}}{hrs} \times \text{CF}$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
ft^2_{door} = Area of cooler or freezer door opening, in square feet
$(\Delta kWh/ft^2)_{door}$ = Annual electric energy savings per square foot of door opening
hrs = Annual cooler or freezer operating hours per year
CF = Coincidence Factor

Summary of Variables and Data Sources

Variable	Value	Notes
ft^2_{door}		From application.
$(\Delta kWh/ft^2)_{door}$		Look up in Deemed Savings table below based on case type and application.
hrs		Lookup from table in Operating Hours section below based on case type and application.
CF	1.0	

[767] 10 CFR 431.302

Deemed Savings ($\Delta kWh/ft^2)_{door}$[768]

Case Type	Application	ΔkWh/ft²
Cooler (> 32°F)	Supermarket	159
	Restaurant	18
	Convenience Store	14
Freezer (≤ 32 °F)	Supermarket	409
	Restaurant	77
	Convenience Store	16

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 1.0[769]

Baseline Efficiencies from which Savings are Calculated

The baseline condition efficiency is a walk-in cooler or freezer door with damaged or missing strip curtains in excess of 15% of the door area.[770]

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a walk-in cooler or freezer with repaired or replaced strip curtains covering the entire open door area.

Operating Hours

Annual hours during which the door is open and strip curtains are therefore preventing heat exchange between the refrigerated case and ambient air is used to determine an estimate of associated demand savings. Prescribed annual hours for formulation of demand savings are provided in the table below.[771]

Case Type	Application	hrs
Cooler (> 32°F)	Supermarket	803
	Restaurant	620
	Convenience Store	230
Freezer (≤ 32 °F)	Supermarket	55
	Restaurant	270
	Convenience Store	230

Effective Useful Life (EUL)

See Appendix P.

[768] ADM Associates, Inc. Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation, Table 6-3, p. 6-6.
[769] *No source specified – update pending availability and review of applicable references.*
[770] ADM Associates, Inc. Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation, p. 6-10
[771] ADM Associates, Inc. Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation, Table 6-5, p. 6-10

Ancillary Fossil Fuel Savings Impacts

Reduction in heat transfer between the refrigerated case and ambient air during periods when the main door is open will result in a small reduction in space heating requirements and a small increase in cooling requirements. This impact is negligible and is not considered in this methodology.

Ancillary Electric Savings Impacts

Reduction in heat transfer between the refrigerated case and ambient air during periods when the main door is open will result in a small reduction in space heating requirements and a small increase in cooling requirements. This impact is negligible and is not considered in this methodology.

References

1. 10 CFR 431.302 Definitions concerning walk-in coolers and walk-in freezers. Available from: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=863517ec5f69fb78dad68864aa84c128&mc=true&n=pt10.3.431&r=PART&ty=HTML#se10.3.431_1302
2. ADM Associates, Inc. "Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation," California Public Utilities Commission Energy Division, February 18, 2010. Available from: http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf

Record of Revision

Record of Revision Number	Issue Date
1-16-16	12/31/2015
3-18-16	3/29/2018

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Freezer and Cooler Door Gaskets

Measure Description

This measure covers the replacement of reach-in and walk-in refrigerated display case door gaskets that have become damaged due to normal use and/or the failure of anti-condensate heater elements. When damaged and/or missing, the warmer, more humid air present in the store will infiltrate the case increasing the refrigeration system load while often reducing the efficiency of the evaporator unit as a result of frost accumulation. This measure applies to gaskets on both reach-in doors and the main door of walk-in units typical of supermarkets, convenience stores, and restaurants.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = ft_{door} \times (\Delta kWh/ft)$$

Peak Coincident Electric Demand Savings

$$\Delta kW = \frac{ft_{door} \times (\Delta kWh/ft)}{8{,}760} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
ft_{door} = Linear feet of damaged and/or missing door gasket
(ΔkWh/ft) = Annual electric energy savings per linear foot of damaged and/or missing door gasket
CF = Coincidence factor
8,760 = Hours per year

Summary of Variables and Data Sources

Variable	Value	Notes
ft_{door}		From application.
(ΔkWh/ft)	Cooler (>32 °F): 15 Freezer (<32 °F): 114	Annual kWh per linear foot of replaced door gasket.[772]
CF	1.0	

[772] ADM Associates, Inc., Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation, February 2010, Table 5-3, Assumes baseline gaskets are 50% effective.

Coincidence Factor (CF)

The prescribed coincidence factor for this measure is 1.0.[773]

Baseline Efficiencies from which Savings are Calculated

The baseline condition is premised on a door with damaged and/or missing gaskets, assumed to be 50% effective.

Compliance Efficiency from which Incentives are Calculated

The compliance condition is the installation of intact door gaskets so as to achieve a minimum 1.5% infiltration rate or lower.

Operating Hours

Refrigeration equipment is assumed to be available for operation 8,760 hours per year.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction of ambient air infiltration into the refrigerated case due to improved gaskets reduces the space heating requirements in the heating season while increasing the cooling load in the cooling season. These impacts are not quantified in this methodology.

Ancillary Electric Savings Impacts

Reduction of ambient air infiltration into the refrigerated case due to improved gaskets, reduces the space heating requirements in the heating season while increasing the cooling load in the cooling season. These impacts are not quantified in this methodology.

References

1. ADM Associates, Inc. "Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation" February 18, 2010, California Public Utilities Commission Energy Division Available from: http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf

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

Record of Revision

Record of Revision Number	**Issue Date**
1-16-17	12/31/2015
6-18-14	6/26/2018

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REFRIGERATION - CONTROL

ANTI-CONDENSATION HEATER CONTROL

Measure Description

This measure covers the installation of anti-condensation heater controls on glass door reach-in refrigerated cases. These controls save energy by reducing door heater run times based on feedback from door moisture sensors or dew point calculated via indoor air temperature and humidity sensors. Additional savings are achieved through interactive effects with the system's compressor. By running less often, door heaters emit less heat that must be overcome by the compressor. There are two primary categories of anti-condensation heater controls – (1) on/off controls and (2) pulse modulating controls. On/off controls cycle door heaters for several minutes at a time whereas pulse modulating controls pulse the door heaters at varying frequencies to satisfy calls for heating.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = (kW_{DH} \times hrs_{baseline}) - (kW_{DH} \times F_{PA} \times hrs_{ee})$$

Peak Coincident Demand Savings

$$\Delta kW = kW_{DH} \times F_{hrs} \times DF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
kW_{DH}	= Total power of door heaters (in kW)
hrs	= Operating hours
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
F_{PA}	= Power adjustment factor
F_{hrs}	= Operating hours reduction factor
DF	= Demand diversity factor

Summary of Variables and Data Sources

Variable	Value	Notes
kW_{DH}		From application, calculated based on door heater nameplate voltage and amperage.
$hrs_{baseline}$	8,760	Pre-installation operating hours; assumes 24/7, year-round operation of door heaters
hrs_{ee}	Coolers: 3,760 Freezers: 8,760	Post-installation operating hours. Freezer hours assume 24/7, year round operation of door heaters and varying power factors. Cooler hours estimated by National Resource Management (NRM) based on monitoring data collected of cooler door heater controls.[774]
F_{PA}	Coolers: 0.60 Freezers: 0.54	Average operating percentage of total door heater power after installation. Estimated by NRM based on monitoring data collected of cooler and freezer door heater controls. F_{PA} for freezers is calculated based on 4,000 hours of operation at 40% power and 4,760 hours at 65%.[775]
F_{hrs}	Coolers: 0.74 Freezers: 0.46	Annual operating hour reduction factor. Estimated by National Resource Management (NRM) based on monitoring data collected of cooler and freezer door heater controls.[776]
DF	0.75	Estimated adjustment to account for diversity and peak coincidence.[777]

Coincidence Factor (CF)

The prescribed value for the coincidence factor is N/A. Adjustments to account for peak coincidence are embedded in the demand diversity factor defined above.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a glass door reach-in refrigerated case anti-condensation heaters without temperature/humidity sensing controls.

Compliance Efficiency from which Incentives are Calculated

The compliance case is a glass door reach-in refrigerated case with on/off or pulse modulating anti-condensation heater controls installed.

[774] *REVIEW OF UNDERLYING REFERENCE PENDING:* Cooler Control Measure Impact Spreadsheet User's Manual, Select Energy Services, Inc., March 2004
[775] Ibid.
[776] Ibid.
[777] Ibid.

Operating Hours

Anti-condensation door heaters without automated controls operate 24/7 year-round (8,760 hours annually). Operating hours for the compliance case are as specified above.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

Reduction of door heater operation will slightly increase space heating load. However, these impacts are negligible and not considered at this time.

Ancillary Electric Savings Impacts

Reduction in door heater operation reduces heat that must be displaced by the compressor. Interactive effects are addressed in the prescribed energy savings calculation methodology.

References

1. National Resource Management monitoring data pending review.
2. *Cooler Control Measure Impact Spreadsheet Users' Manual*, Select Energy Services, Inc. for NSTAR, March 9, 2004
3. California Public Utilities Commission: Database for Energy Efficient Resources (DEER) – 2014, Updated-EULrecords_02-07-2014; EUL ID: GrocDisp-ASH. Available from: http://deeresources.com/files/deerchangelog/deerchangelog.html

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
9-17-10	9/30/2017

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EVAPORATOR FAN CONTROL

Measure Description

This measure covers the installation of on/off or multispeed controls on electronically commutated or shaded pole evaporator fan motors in walk-in refrigerated cases. Evaporator fans in walk-in coolers and freezers that are not equipped with controls operate at constant speed continuously, even when there is no call for refrigeration and the compressor is idle. Installation of controls allows for modulation of evaporator fans, reducing fan speed or turning them off when the compressor is not running. Reduction in energy consumption results from reduced run time of the evaporator fans as well as reduction in waste heat due to fan operation that must be rejected by the system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of evaporator fans controlled
hp = Horsepower per evaporator fan
(ΔkWh/hp) = Annual electric savings per evaporator fan horsepower
(ΔkW/hp) = Peak coincident demand electric savings per evaporator fan horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application. If unknown, assume 1/15 hp.[778]
(ΔkWh/hp)		Lookup from Deemed Savings table below based on case type, evaporator fan motor type and control type.
(ΔkW/hp)		Lookup from Deemed Savings table below based on case type, evaporator fan motor type and control type.

[778] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, pg. 6

Deemed Savings (ΔkWh/hp and ΔkW/hp)[779]

Case Type	Motor Type	Control Type	ΔkWh/hp	ΔkW/hp
Cooler	Shaded Pole	On/Off	8,650	0.776
		Multispeed	7,224	0.741
	ECM	On/Off	3,142	0.282
		Multispeed	2,624	0.269
Freezer	Shaded Pole	On/Off	10,991	0.990
		Multispeed	9,178	0.945
	ECM	On/Off	3,992	0.360
		Multispeed	3,334	0.343

Coincident Factor (CF)

Demand savings provided in the table above represent peak coincident summer demand savings. Coincidence factor is embedded in deemed savings values; therefore, no coincidence factor is independently prescribed.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is a walk-in cooler or freezer with shaded pole or electronically commutated evaporator fan motors that operate continuously at constant speed (i.e. with no controls installed).

Compliance Efficiency from which Incentives are Calculated

The compliance condition is a walk-in cooler or freezer with shaded pole or electronically commutated evaporator fan motors equipped with on/off or multispeed evaporator fan controls.

Operating Hours

Annual evaporator fan operating hours for the baseline and proposed case are embedded in the deemed savings values provided above. It is assumed that evaporator fans without controls have an effective full load annual run time of 97.8% x 8,760 = 8,567 hours. The effective full load annual run time of evaporator fans with on/off control are assumed to be 63.6% x 8,760 = 5,571 hours, while the effective full load annual run time of evaporator fans with multispeed control are assumed to be 69.2% x 8,760 = 6,062 hours.

Effective Useful Life (EUL)

See Appendix P.

Ancillary Fossil Fuel Savings Impacts

N/A

[779] ΔkW/hp savings are calculated by dividing Summer Peak Savings (W/hp) by 1,000W/kW to convert it to the appropriate units. Cadmus, Commercial Refrigeration Loadshape Project, October 2015, pg. 10.

Ancillary Electric Savings Impacts

N/A

References

1. Cadmus, Commercial Refrigeration Loadshape Project, October 2015
   Available from: www.neep.org/file/3530/download?token=NnVjANtf

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-16	7/31/2013
1-16-8	12/31/2015
3-18-5	3/29/2018

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CUSTOM MEASURES

This section is designed to provide New York's program administrators (PAs) with additional clarification of the DPS review and oversight procedures for custom measures and applications. The overriding DPS goal is to conduct its oversight responsibilities in a manner that protects ratepayer dollars without unduly limiting the ability of PAs to meet their energy savings goals and administer their programs effectively.

The PAs have the responsibility to develop accurate and unbiased estimates of energy savings of custom projects including addressing quality control, project application review, and energy savings calculations. The processes used by PAs to meet these responsibilities will be reviewed by DPS to ensure accountability and transparency. To minimize the impact on the delivery of services through currently operating programs, PAs may continue to operate their programs while the DPS review process is ongoing.

DEFINITIONS

Quality Control (QC) – Policies and procedures established by the PA to ensure the quality of the energy efficiency measures and services delivered to customers. Quality control activities may include factors such as the minimum requirements for energy calculations, model calibration to billing data, application review criteria, reporting requirements, pre and/or post inspections, measurement and verification (M&V) of energy savings, and qualifications of service providers.

Quality Assurance (QA) – Third party verification activities that ensure QC policies and procedures established by the PAs are working as intended, and provide recommendations for modification of QC policies and procedures as necessary.

Prescriptive Measure – Measure which is offered within specific efficiency programs with a prescribed incentive amount or level for all customers participating in the applicable programs. Not all prescriptive measures are necessarily prequalified (i.e., approved by the DPS for offering within a program).

Prequalified Measure – Measure reviewed for cost-effectiveness by the DPS and approved for offering within a program. All prequalified measures are prescriptive measures, but it is the responsibility of the PAs to ensure that all prequalified measures are cost effective within their programs.

Custom Measure – The traditional definition of a custom measure involves unique, and often complex, technologies and processes installed in large facilities. A detailed engineering analysis is usually required and incentives are offered based on the site-specific expected energy savings and costs. Energy savings are estimated using a site-specific engineering analysis. The engineering analysis technique is chosen based on the measure and facility type with the calculations driven by site and measure-specific data. For our purposes, this category also covers infrequently implemented measures or applications that are not listed in an existing prescriptive program.

EEPS/SBC CUSTOM MEASURES

(Four Categories)

For the EEPS and SBC energy efficiency programs custom measures includes the following four categories:

Measures that are not included in the TRM and are unique to a specific non-standard process or application, as application conditions can substantially change from project to project. For example, this category might include custom industrial processes, snowmaking, and computer chip fabrication facilities.

Measures that are not in category 1, including prescriptive measures that are promoted by the programs, but are not included in the TRM. Examples in this category include EC motors on HVAC system fans and indirect water heaters.

Measures that are in the TRM, but that are installed in a different environment or have a different use conditions than those assumed in the TRM. Examples in this category include certain comprehensive chiller and cooling tower upgrades.

Measures that are in the TRM, but that require simulation modeling or other advanced approaches in order to estimate interactive effects within a facility (if different from category 3). Examples in this category include whole-building performance programs addressing single and multi-family projects and commercial new construction.

CATEGORY 1 – UNIQUE MEASURES/PROJECTS

This section outlines the DPS's policy for reviewing quality control and quality assurance policies and procedures for programs offering measures unique to a specific non-standard process or application.

Critical review of the project energy savings projections and costs is essential to ensure projects are cost-effective and deliver the expected savings. This is especially important for one-of-a-kind projects, where the savings are large, and the expertise needed to understand and verify energy savings projections is specialized. DPS expects that the PAs will utilize an internal process for reviewing and approving large custom projects including screening for cost-effectiveness. DPS will review this process for completeness and transparency. PAs offering large custom incentive programs must also submit their QC and QA processes to the DPS for review. Any issues resulting from these reviews will be reported to the PAs, along with a list of requirements and a schedule for resolving these issues. The QC and QA functions may be staffed internally or provided by outside contractors. Contractors must possess appropriate certification and demonstrated expertise in the technology or processes proposed for the project. As a component of the QC and QA process review, the qualifications of contractors will be reviewed by the DPS.

If the PA has an existing impact evaluation study capable of informing the energy savings of a custom measure(s), this study may serve as the basis for reporting energy savings, provided the study is reviewed by DPS and meets current EEPS evaluation guidelines and standards.

In order to keep the DPS informed of projects and to assist in its review, the PAs will submit monthly reports showing the progress of all "unique" custom projects in the review and approval pipeline. The report must include a description of customer type and the proposed project, the stage of development, energy and demand savings estimates including baseline assumptions, and the expected approval and construction schedule. The DPS, at its discretion, will review selected projects. The DPS will inform the PAs of its intent to review selected projects and provide the PAs with a review schedule.

As part of the PAs evaluation plan, PAs must conduct impact evaluation on a sample of these custom projects to verify the estimated energy savings. Staff may require a project specific impact evaluation for very large projects. Realization rates will be reviewed and possibly revised as evaluation studies provide more data.

CATEGORY 2 – MEASURES INCLUDING PRESCRIPTIVE MEASURES NOT IN THE TRM

The DPS understands that PAs are offering, or will be offering, incentives for measures not included in the TRM. It is the responsibility of the PAs to ensure that all measures are cost effective. The DPS will review the calculation procedures used by the PAs to estimate energy savings, set incentive levels, and show cost-effectiveness. The calculation reviews will be used to verify energy savings and cost-effectiveness, reconcile differences between PAs offering similar measures, and along with results from impact evaluations, inform updates of the TRMs.

PAs must submit calculations for review in a timely manner. The DPS will establish a priority for reviewing these calculations based on the expected number of program applications and the expected uncertainty in the energy savings estimates. PAs can report energy savings using their internal estimates prior to the completion of the calculation reviews. Once the reviews are completed and the energy savings adjustments are identified, the DPS will establish a schedule for incorporating the revised energy savings estimates into the reporting process.

CATEGORY 3 – MEASURES IN TRM BUT USED IN A DIFFERENT APPLICATION/ENVIRONMENT

The DPS will review the PAs processes for reviewing and approving these custom installations, along with the associated QC and QA policies and procedures. Project review and approval must include a cost-effectiveness screening for each custom project. The QC and QA functions may be staffed internally or provided by outside contractors. Contractors must possess appropriate certification and demonstrated expertise in the technology or processes proposed for the project. As a component of the QC and QA process review, the qualifications of contractors will be reviewed by the DPS.

If the PA has an existing impact evaluation study capable of informing the energy savings of a custom measure(s), this study may serve as the basis for reporting energy saving provided that the study is reviewed by the DPS and the meets current EEPS evaluation guidelines and standards.

The DPS will review procedures used to verify energy savings and approve projects for incentives. Processes used to establish project baselines and energy savings, including engineering analysis tools and simulation software, will be reviewed by the DPS. The DPS may review a sample of project energy savings and cost-effectiveness calculations to check compliance with the approved internal QC processes. Any issues resulting from DPS reviews will be reported to the PAs, along with a list of requirements and a schedule for resolving these issues.

As part of the evaluation plan, PAs must conduct impact evaluations on at least a sample of custom measures to verify the estimated energy savings. Staff may require a project specific impact evaluation for very large projects. Realization rates will be reviewed by the DPS and possibly revised as evaluation studies provide more data.

Category 4 – Whole-Building Analysis

The whole-building approach is commonly applied to new construction projects (both residential and commercial) and specialized retrofit programs such as the Home Performance with ENERGY STAR®. These programs use a building energy simulation model to calculate energy savings for a combination or "package" of measures. The building energy simulation models are informed by detailed building audits and may include building diagnostic testing to identify energy savings opportunities.

Many of the PAs have developed internal processes for reviewing and verifying savings estimates developed under the whole-building analysis approach. PAs offering programs utilizing the whole-building approach must submit their QC and QA processes to the DPS for review. Any issues resulting from DPS reviews will be reported to the PAs along with a list of requirements and a schedule for resolving these issues. The QC and QA functions may be staffed internally or provided by outside contractors. Contractors must possess appropriate certification and demonstrated expertise in whole-building performance analysis. As a component of the QC and QA process review, the qualifications of contractors will be reviewed by the DPS.

The DPS will review the processes used to establish project baselines and energy savings estimates, including requirements for calibrating models to measured data or benchmarking results to established energy metrics. This effort will include a review of analysis tools and simulation software including the administrator's expertise in their application. Evidence of certifications by a third party organization such as the Building Performance Institute or RESNET would be helpful and should be provided by the PA, if available. At the discretion of the DPS, a sample of project energy savings and cost-effectiveness calculations will be reviewed to check compliance with the approved internal QC processes.

Since the measures contained within the package can influence and interact with each other, the whole building analysis gives a good representation of the savings of the overall package of measures, but does not necessarily provide the information needed to understand the contributions of individual measures to the total savings estimate. It is also difficult to isolate the costs of each energy savings measure from the total project cost (especially in new construction projects). As a result, individual measure cost-effectiveness screening is difficult to conduct within a whole-building analysis framework. Although the overall project may be cost effective, there may be "cross subsidies", where highly cost effective measures are compensating for the lack of cost-effectiveness of other measures. Each measure should be cost effective on its own.

As part of the PAs evaluation plan, PAs must conduct impact evaluation on at least a sample of custom projects to verify the estimated energy savings. Staff may require a project specific impact evaluation for very large projects. Realization rates will be reviewed and possibly revised as evaluation studies provide more data.

Recommended Application Review and QC Procedures for Custom Programs
As stated above, the DPS will conduct reviews of the application review and QC procedures in place for custom programs. The following tables provide a list of issues the application review QC procedures for custom programs should address.

Energy Savings Calculations

Issue	Criteria
Baseline definition	List the criteria used to define the project baseline. The DPS will issue further clarification on baseline requirements in a separate document.
Energy savings calculation methods	List acceptable calculation methods, including approved building energy simulation models and other software
Calibration	Define when calculations must be calibrated with measured data. The acceptable sources of measured data should be defined. The calibration statistics in terms of allowable deviation between calculations and measured data should be defined along with allowable adjustment ranges on important input parameters.
Calculations outside of approved tools	When approved tools are required, list restrictions on calculations that can be performed outside of the tools.
Simulation guidelines	Provide general guidance on acceptable modeling practices for building energy simulation models.
Field measurement requirements	List requirements for field measurements that must be taken and included in the measure savings calculation process.

Application Review Process

Issue	Criteria
Program applicability	Check that the application meets each of the program applicability requirements.
Measure cost requirements	Provide guidance on acceptable sources and processes for estimating measure costs. Clarify the need for full measure costs and incremental costs, and breakdowns by labor and materials as required.

Issue	Criteria
Cost-effectiveness calculation method	Provide guidance on how cost-effectiveness calculations should be done, including the required formulas and data sources. Spreadsheets and other software tools conforming to approved cost-effectiveness calculation procedures may be used to meet this requirement.
Consideration of non-energy benefits (NEBs)	Describe requirements for identifying and quantifying expected non-energy benefits as applicable.
Application approval procedures	Describe the application review procedures, including the affiliations and qualifications of reviewers.

Project QC Procedures

Issue	Criteria
Sampling requirements	Describe sampling procedures used to review projects, including numbers of projects reviewed and the distribution of the sample across contractors and consultants. Describe sampling procedures for measures within a particular project as required.
Pre Inspections	Describe requirements for pre-installation inspections, including data collection requirements and the role of pre-installation inspections in the energy savings calculations.
Post inspections	Describe requirements for post-installation inspections, including data collection requirements and the role of post-installation inspections in the energy savings calculations, measure verification and incentive payment release.
Performance testing	Describe requirements for performance testing of measures as a component of post-installation measure installation verification and incentive payment release.
Commissioning	Describe requirements for project or building commissioning as applicable, including review and approval of commissioning plans and qualifications of commissioning agents and/or service providers.
M&V	Describe post-installation M&V requirements and the role of M&V in project verification and incentive payment release.
Contractor certification	Describe certification requirements for contractors providing project construction and quality control services.
Minimum experience	In addition to certifications, any minimum experience requirements for contractors should be listed.
Training	List requirements for ongoing training.
PA notification requirements	Protocols for informing a PA representative of issues with project quality should be described.

Consultant QC Procedures

Issue	**Criteria**
Reporting requirements	Minimum requirements for consultant reports should be described.
Report review and approval	The report review procedures and affiliations and qualifications of report reviewers should be described.
Evaluation criteria	Evaluation criteria for consultant QC reviews should be listed.
Sampling requirements	Sampling procedures for consultant QC reviews should be described.
Consultant certifications	Certification requirements for consultants should be listed.
Consultant skills and experience	Beyond basic certification requirements, a description of the skill and experience requirements for consultants should be listed.
PA notification requirements	Protocols for informing a PA representative of issues with consultant services quality should be described.

Record of Revision

Record of Revision Number	**Issue Date**
0	10/15/2010

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APPENDIX A

BUILDING TYPES

The sections that follow provides savings data by building type. A description and additional details of each building type is shown in the table below and the sections that follow.

Note: the building type classifications are defined primarily by activity, HVAC system type, and number of floors since the deemed parameters in the TRM are generally normalized to equipment or measure size.

Building Type	*Description*
Assembly	Public buildings that include community centers, libraries, performance and movie theaters, auditoria, police and fire stations, gymnasia, sports arenas, and transportation terminals
Auto	Repair shops and auto dealerships, including parking lots and parking structures.
Big Box	Single story, high-bay retail stores with ceiling heights of 25 feet or more. Majority of floor space is dedicated to non-food items, but could include refrigerated and non-refrigerated food sales areas.
Community College	Community college campus and post-secondary technical and vocational education buildings, including classroom, computer labs, dining and office. Conditioned by packaged HVAC systems
Dormitory	College or University dormitories
Fast Food	Self-service restaurants with primarily disposable plates, utensils etc.
Full Service Restaurant	Full service restaurants with full dishwashing facilities
Grocery	Refrigerated and non-refrigerated food sales, including convenience stores and specialty food sales
Heavy Industrial	Single or multistory buildings containing industrial processes including pump stations, water and wastewater treatment plants; may be conditioned or unconditioned.
Hospital	Inpatient and outpatient care facility conditioned by built-up HVAC systems. Excludes medical offices
Hotel	Multifunction lodging facility with guest rooms, meeting space, foodservice conditioned by built-up HVAC system
Industrial Refrigeration	Refrigerated warehouses and food processing facilities maintained at space temperatures of 55 °F or less.
Large Office	Office space in buildings greater than 3 stories conditioned by built-up HVAC system.
Light Industrial	Single story work space with heating and air-conditioning; conditioned by packaged HVAC systems
Multi-family high-rise	Multi-family building with more than 3 stories conditioned by built up HVAC system
Multi-family low-rise	Multi-family building with 3 stories or less conditioned by packaged HVAC system
Motel	Lodging facilities with primarily guest room space served by packaged HVAC systems
Multi Story Retail	Retail building with 2 or more stories served by built-up HVAC system
Primary School	K-8 school
Religious	Religious worship

Building Type	*Description*
Secondary School	9-12 school
Single-family residential	Single-family detached residences
Small Office	Office occupancy in buildings 3 stories or less served by packaged HVAC systems; includes Medical offices
Small Retail	Single story retail with ceiling height of less than 25 feet; primarily non-food retail and storage areas served by packaged HVAC systems. Includes service businesses, post offices, Laundromats, and exercise facilities.
University	University campus buildings, including classroom, computer labs, biological and/or chemical labs, workshop space, dining and office. Conditioned by built-up HVAC systems
Warehouse	Primarily non-refrigerated storage space could include attached offices served by packaged HVAC system.

Note: for commercial buildings that cannot be reasonably associated with one the building types above, savings values for the "other" category should be used.

PROTOTYPICAL BUILDING DESCRIPTIONS

RESIDENTIAL BUILDING PROTOTYPES

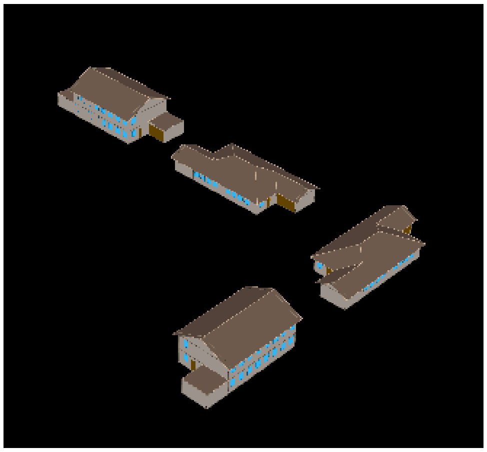
Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[780] study, with adjustments made for local building practices and climate. Three separate models were created to represent general vintages of buildings:

- Old, poorly insulated buildings constructed before 1979, before the NY State Energy Code went into effect. This vintage is referred to as the "old" vintage.
- Existing, average insulated buildings conforming to 1980s era building codes. This vintage is referred to as the "average" vintage, covering buildings constructed from 1979 to 2006.
- New construction conforming to the 2007 Energy Conservation Construction Code of New York State (ECCCNYS) for residential buildings. This vintage is referred to as the "new" vintage, and covers buildings constructed from 2007 to present.

SINGLE-FAMILY RESIDENTIAL PROTOTYPE

The single-family "model" in fact contains four separate residential buildings: 2 one-story and 2 two-story buildings. Each version of the 1 story and 2 story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these four buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures. A sketch of the single-family residential prototype buildings is shown below.

[780] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf



The general characteristics of the single-family residential building prototype model are summarized below.

SINGLE-FAMILY RESIDENTIAL BUILDING PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Three vintages simulated – old poorly insulated buildings, existing average insulated buildings and new buildings
Conditioned floor area	1 story house: 1465 SF (not including basement) 2 story house: 2930 SF (not including basement)
Wall construction and R-value	Wood frame with siding, R-value varies by vintage
Roof construction and R-value	Wood frame with asphalt shingles, R-value varies by vintage
Glazing type	Single and double pane; properties vary by vintage
Lighting and appliance power density	0.51 W/SF average
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	Baseline SEER = 13
Thermostat set points	Heating: 70°F with setback to 67°F Cooling: 75°F with setup to 78°F
Duct location	Buildings without basement: attic Buildings with basement: basement
Duct surface area	Single story house: 390 SF supply, 72 SF return Two story house: 505 SF supply, 290 SF return
Duct insulation	Uninsulated
Duct leakage	20% of fan flow total leakage evenly split between supply and return.
Natural ventilation	Allowed during cooling season when cooling set point exceeded and outdoor temperature < 65°F. 3 air changes per hour

Wall, Floor and Ceiling Insulation Levels

The assumed values for wall and ceiling by vintage are shown below.

WALL INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated wall	Notes
Older, poorly insulated	4.8	No insulation in 2 by 4 wall; 3.5 in. air gap resistance only
Existing, average insulation	11	Fiberglass insulation in 2 by 4 wall per MEC 1980
New construction	19	Code

CEILING INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Older, poorly insulated	11	Minimal ceiling insulation
Existing, average insulation	19	Fiberglass insulation per MEC 1980
New construction	30 (NYC), 38 (all others)	Code

Windows

The glazing U-value and solar heat gain coefficient (SHGC) assumptions for the three vintages are shown below.

WINDOW PROPERTY ASSUMPTIONS BY VINTAGE

Vintage	U-value (BTU/hr-F-SF)	SHGC	Notes
Older, poorly insulated	0.93	0.87	Single pane clear
Existing, average insulation	0.87	0.77	Double pane clear
New construction	0.28	0.49	Double low e

Infiltration

Infiltration rate assumptions were set by vintage as shown below.

INFILTRATION RATE ASSUMPTIONS BY VINTAGE

Vintage	Assumed infiltration rate	Notes
Older, poorly insulated	1 ACH	
Existing, average insulation	0.5 ACH	
New construction	0.35 ACH	Minimum without forced ventilation per ASHRAE Standard 66.

MULTI-FAMILY LOW-RISE

The low-rise prototype "model" in fact contains 2 separate buildings. Each version of the buildings is identical except for the orientation, which is shifted by 90 degrees. The selection of these 2 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures.

Four separate models were created to represent general vintages of buildings:

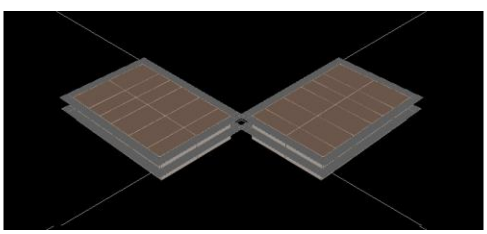
- Built prior to 1940, uninsulated masonry buildings. This vintage is referred to as "Pre-war uninsulated brick."

- Built prior to 1979 when the NYS Energy Code (known as the Energy Conservation Construction Code of New York State – ECCCNYS) went into effect, poorly insulated wood-frame buildings This vintage is referred to as "Prior to 1979"

- Built from 1979 through 2006, with insulation conforming to 1980s era building codes (1979 ECCCNYS.) This vintage is referred to as "From 1979 through 2006."

- Built from 2007 through the present, new construction with insulation conforming to the 2007 ECCCNYS for residential buildings and the New York City Energy Conservative Construction Code (if applicable.) This vintage is referred to as "From 2007 through the present."

Each building vintage was run with 7 different HVAC system types to capture the range of HVAC systems common in low-rise multi-family buildings. A sketch of the low-rise prototype buildings is shown below.



The general characteristics of the residential building prototype model are summarized below.

MULTI-FAMILY LOW-RISE RESIDENTIAL BUILDING PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Four vintages simulated: Pre-war uninsulated brick; Prior to 1979 (wood frame); From 1979-2006; and From 2007 to present
Conditioned floor area	949 SF per unit; 6 units per floor, 2 floors per building, 11,388 SF total.
Wall construction and R-value	R-value and construction vary by vintage.
Roof construction and R-value	Wood frame with asphalt shingles. R-value varies by vintage.
Glazing type	Single or double pane. Properties vary by vintage.
Lighting and appliance power density	0.87 W/SF average in bedrooms, 0.58 W/SF in living space.

Characteristic	Value
HVAC system types	1. Split system AC with central gas heat 2. Split system AC with electric heat 3. Split system heat pump 4. PTAC with electric heat 5. PTHP 6. Electric heat only (no AC) 7. Central gas heat only (no AC) 8. Central steam (within the building) heat only (no AC)
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	AC and heat pump: SEER = 13 PTAC and PTHP: EER = 7.7 Furnace / boiler: AFUE = 78% Steam boiler: AFUE = 75%
Thermostat set points	1. Heating: 70^{0}F with setback to 67^{0}F(other than NYC); 73^{0}F with setback to 70^{0}F (NYC only) 2. Cooling: 75°F with setup to 78°F
Duct location (for systems with ducts)	In attic and plenum space between first and second floors. PTACs and PTHPs have no ductwork.
Duct surface area (for systems with ducts)	256 SF supply, 47 SF return per system
Duct insulation (for systems with ducts)	Uninsulated
Duct leakage (for systems with ducts)	20% of fan flow total leakage, evenly split between supply and return.
Natural ventilation	Allowed during cooling season when cooling set point exceeded and outdoor temperature < 65°F. 3 air changes per hour

Wall and Ceiling Insulation Levels

The assumed values for wall and ceiling by vintage are below.

WALL INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated wall	Notes
Pre-war uninsulated brick	4	Three 4" brick layers. No insulation. 2" air gap resistance only.
Prior to 1979	7	Wood frame with siding. No insulation in 2 by 4 wall; 3.5" air gap resistance only
From 1979 through 2006	11	Wood frame with siding. Fiberglass insulation in 2 by 4 wall per MEC 1980.
From 2007 through the present	19	Code

CEILING INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Pre-war uninsulated brick	2	No ceiling insulation
Prior to 1979	11	Minimal ceiling insulation
From 1979 through 2006	19	Fiberglass insulation per MEC 1980
From 2007 through the present	38	NYS Code for climate zones 4 & 5
	49	NYS Code for climate zone 6

THERMOSTATIC HEATING SET POINT ASSUMPTIONS BY VINTAGE

Vintage	Set point and setback (°F)	Notes
Pre-war uninsulated brick	73, 70	NYC
	70, 67	All others
Prior to 1979	70, 67	
From 1979 through 2006	70, 67	
From 2007 through the present	70, 67	

Windows

The glazing U-value and solar heat gain coefficient (SHGC) assumptions for the four vintages are shown below.

WINDOW PROPERTY ASSUMPTIONS BY VINTAGE

Vintage	U-value (BTU/hr-ºF-SF)	SHGC	Notes
Pre-war uninsulated brick	0.93	0.87	Single pane clear
Prior to 1979	0.93	0.87	Single pane clear
From 1979 through 2006	0.68	0.77	Double pane clear
From 2007 through the present	0.28	0.49	Double low e per code

Infiltration

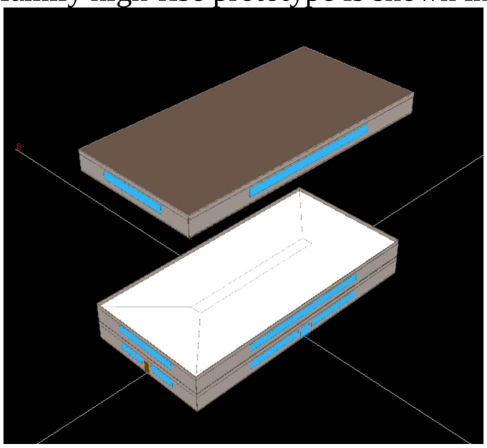
Infiltration rate assumptions were set by vintage as shown below.

INFILTRATION RATE ASSUMPTIONS BY VINTAGE

Vintage	Assumed infiltration rate	Notes
Pre-war uninsulated brick	1 ACH	
Prior to 1979	1 ACH	
From 1979 through 2006	0.5 ACH	
From 2007 through the present	0.35 ACH	Minimum without forced ventilation per ASHRAE Standard 66.

MULTI-FAMILY HIGH-RISE

The multi-family high-rise model was developed using the conceptual design "wizard" in eQUEST program, rather than a DEER prototype. A computer-generated sketch of the multi-family high-rise prototype is shown in the figure below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and the results are multiplied by 8 to represent the energy consumption of the 8 middle floors. The general characteristics of the multi-family high-rise building prototype model are summarized below.

MULTI-FAMILY HIGH-RISE RESIDENTIAL BUILDING PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Four vintages simulated: Pre-war uninsulated brick; Prior to 1979 (wood frame); From 1979-2006; and From 2007 to present
Conditioned floor area	810 SF per unit; 10 units per floor, 10 floors per building; 81,000 SF total living space. Corridors and common space: 18,255 SF; Laundry rooms: 6,845 SF Storage: 7,985 SF Total: 114,085 SF
Wall construction and R-value	Masonry wall with brick exterior, R-value varies by vintage
Roof construction and R-value	Wood frame with built-up roofing, R-value varies by vintage
Glazing type	Single or double pane; properties vary by vintage
Lighting and appliance power density	0.7 W/SF average
HVAC system type	1. Four pipe fan coil with air cooled electric chiller and gas hot water boiler 2. Central building steam
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	Chiller: COP = 3.9 Hot water boiler: Thermal efficiency = 78% Steam boiler: thermal efficiency = 75%
Thermostat set points	1. Heating: 70^{0}F with setback to 67^{0}F(other than NYC); 73^{0}F with setback to 700F (NYC only) 2. Cooling: 75°F with setup to 78°F

Wall, Floor Insulation Levels

The assumed values for wall and ceiling by vintage are shown below.

WALL INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated wall	Notes
Pre-war uninsulated brick	4	Same as low-rise
Prior to 1979	7	No insulation; air gap resistance only
From 1979 through 2006	11	Same as low-rise
From 2007 through the present	19	Code

ROOF INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Pre-war uninsulated brick	2	Same as low-rise
Prior to 1979	11	Same as low-rise
From 1979 through 2006	19	Same as low-rise
From 2007 through the present	38	Code for climate zone 4 & 5
	49	Code for climate zone 6

THERMOSTATIC HEATING SET POINT ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Pre-war uninsulated brick	2	Same as low-rise
Prior to 1979	11	Same as low-rise
From 1979 through 2006	19	Same as low-rise
From 2007 through the present	38	Code for climate zone 4 & 5
	49	Code for climate zone 6

Windows

The glazing U-value and solar heat gain coefficient (SHGC) assumptions for the four vintages are shown below.

WINDOW PROPERTY ASSUMPTIONS BY VINTAGE

Vintage	U-value (BTU/hr-F-SF)	SHGC	Notes
Pre-war uninsulated brick	0.93	0.87	Single pane clear
Prior to 1979	0.93	0.87	Single pane clear
From 1979 through 2006	0.68	0.77	Double pane clear
From 2007 through the present	0.28	0.49	Double low E per code

Infiltration

Infiltration rate assumptions were set by vintage as shown below.

INFILTRATION RATE ASSUMPTIONS BY VINTAGE

Vintage	Assumed infiltration rate	Notes
Pre-war uninsulated brick	1 ACH	
Prior to 1979	1 ACH	Same as low-rise
From 1979 through 2006	0.5 ACH	Same as low-rise
From 2007 through the present	0.35 ACH	Minimum without forced ventilation per ASHRAE Standard 66.

COMMERCIAL BUILDING PROTOTYPES

Analysis used to develop parameters for the energy and demand savings calculations is based on DOE-2.2 simulations of a set of prototypical small and large buildings. The prototypical simulation models were derived from the commercial building prototypes used in the California Database for Energy Efficiency Resources (DEER)[781] study, with adjustments made for local building practices and climate.

The primary distinction between small and large buildings is the HVAC system type rather than a specific conditioned floor area criterion. Small buildings in this study utilize packaged rooftop HVAC systems or packaged terminal air conditioners (PTAC). Large buildings use built-up HVAC systems with chillers and boilers.

Note: for purposes of applying the building type specific results to buildings not included in the prototype list, use the "other" category within each applicable measure savings section.

Assembly

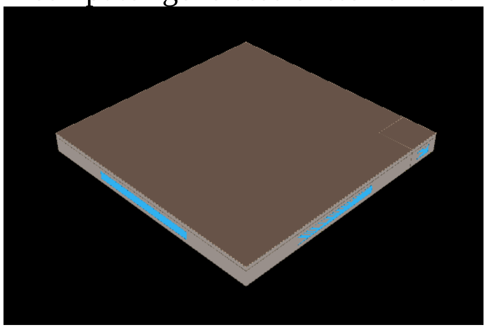
A prototypical building energy simulation model for an assembly building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

ASSEMBLY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 SF Office: 760 SF
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Auditorium: 3.4 W/SF Office: 2.2 W/SF
Plug load density	Auditorium: 1.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sun: 8am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 - 110 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

[781] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

A computer-generated sketch of the Assembly Building prototype is shown below.



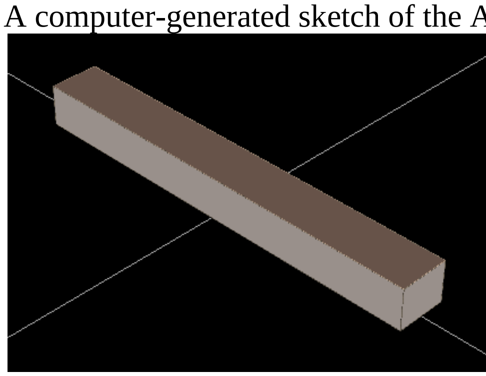
Auto Repair

A prototypical building energy simulation model for an auto repair building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

AUTO REPAIR PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	5150 square feet
Number of floors	1
Wall construction and R-value	Concrete block, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13,5
Glazing type	Double pane clear; SHGC = ,74 U-value = 0,72
Lighting power density	2.2 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sun: 9am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	280 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Auto Repair Building prototype is shown below.



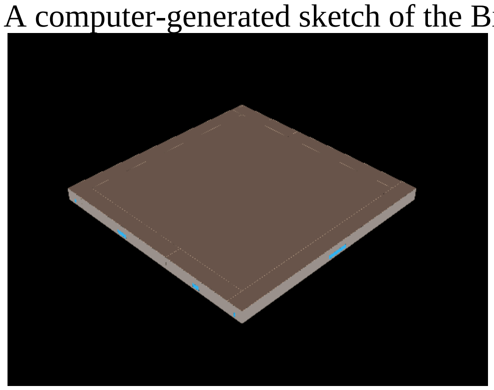
Big Box Retail

A prototypical building energy simulation model for a big box retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

BIG BOX RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 SF Storage: 11,870 SF Office: 4,683 SF Auto repair: 5,151 SF Kitchen: 1,459 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Storage: 0.88 W/SF Office: 2.2 W/SF Auto repair: 2.15 W/SF Kitchen: 4.3 W/SF
Plug load density	Sales: 1.15 W/SF Storage: 0.23 W/SF Office: 1.73 W/SF Auto repair: 1.15 W/SF Kitchen: 3.23 W/SF
Operating hours	Mon-Sun: 10am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 260 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Big Box Building prototype is shown below.



Community College

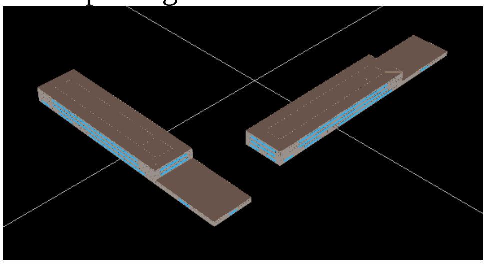
A prototypical building energy simulation model for a community college was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really two identical buildings oriented 90 degrees apart. The characteristics of the prototype are summarized below.

Community College Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 150,000 square feet each; oriented 90° from each other Classroom: 150,825 SF Computer room: 9,625 SF Dining area: 26,250 SF Kitchen: 5,625 SF Office: 70,175 SF Total: 300,000 SF
Number of floors	3
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Community College Building prototype is shown below.



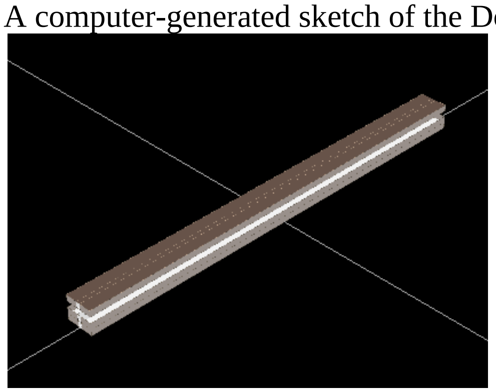
Dormitory

A prototypical building energy simulation model for a university dormitory was developed using the DOE-2.2 building energy simulation program. The dormitory building was extracted from the DEER university prototype and modeled separately. The model consists of two identical buildings oriented 90 degrees apart. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

DORMITORY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	170,000 square feet
Number of floors	4
Wall construction and R-value	CMU with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear; SHGC = 0.73 U-value = 0.72
Lighting power density	Rooms: 0.5 W/SF Corridors and common space: 0.8
Plug load density	Rooms: 0.6 W/SF Corridors and common space: 0.2
Operating hours	24/7 - 365
HVAC system type	Fan coils with centrifugal chiller and hot water boiler
HVAC system size	800 SF/ton
Thermostat set points	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

A computer-generated sketch of the Dormitory Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and the results are multiplied by 2 to represent the energy consumption of the 2 middle floors.

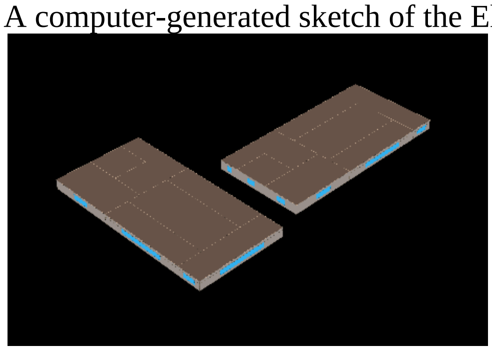
Elementary School

A prototypical building energy simulation model for an elementary school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of two identical buildings oriented in two different directions. The characteristics of the prototype are summarized below.

ELEMENTARY SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 15,750 SF Cafeteria: 3,750 SF Gymnasium: 3,750 SF Kitchen: 1,750 SF
Number of floors	1
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Classroom: 4.4 W/SF Cafeteria: 1.7 W/SF Gymnasium: 2.1 W/SF Kitchen: 4.3 W/SF
Plug load density	Classroom: 1.2 W/SF Cafeteria: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 4.2 W/SF
Operating hours	Mon-Fri: 8am – 6pm Sun: 8am – 4pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	160 - 180 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Elementary School Building prototype is shown below.



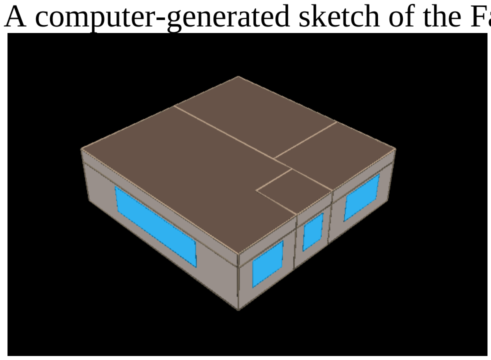
Fast Food Restaurant

A prototypical building energy simulation model for a fast food restaurant was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

FAST FOOD RESTAURANT PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square feet 1,000 SF dining 600 SF entry/lobby 300 SF kitchen 100 SF restroom
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	1.7 W/SF dining 2.5 W/SF entry/lobby 4.3 W/SF kitchen 1.0 W/SF restroom
Plug load density	0.6 W/SF dining 0.6 W/SF entry/lobby 4.3 W/SF kitchen 0.2 W/SF restroom
Operating hours	Mon-Sun: 6am – 11pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 – 120 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

A computer-generated sketch of the Fast Food Building prototype is shown below.



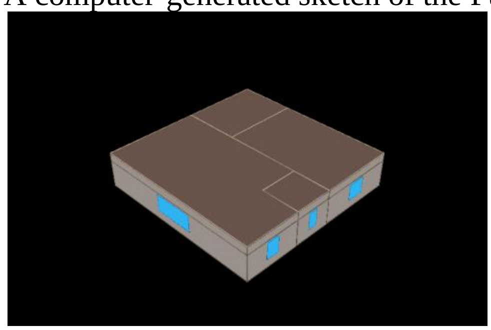
Full-Service Restaurant

A prototypical building energy simulation model for a full-service restaurant was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the full service restaurant prototype are summarized below.

FULL SERVICE RESTAURANT PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square foot dining area 600 square foot entry/reception area 1200 square foot kitchen 200 square foot restrooms
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Dining area: 1.7 W/SF Entry area: 2.5 W/SF Kitchen: 4.3 W/SF Restrooms: 1.0 W/SF
Plug load density	Dining area: 0.6 W/SF Entry area: 0.6 W/SF Kitchen: 3.1 W/SF Restrooms: 0.2 W/SF
Operating hours	9am – 12am
HVAC system type	Packaged single zone, no economizer
HVAC system size	140 – 160 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

A computer-generated sketch of the Full-Service Restaurant Building prototype is shown below.



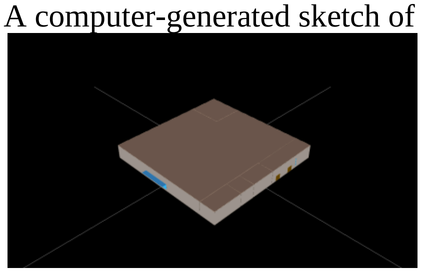
Grocery

A prototypical building energy simulation model for a grocery building was developed using the DOE-2.2R[782] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

GROCERY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	50,000 square feet Sales: 40,000 SF Office and employee lounge: 3,500 SF Dry storage: 2,860 SF 50 °F prep area: 1,268 SF 35 °F walk-in cooler: 1,560 SF - 5 °F walk-in freezer: 812 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Office: 2.2 W/SF Storage: 1.82 W/SF 50°F prep area: 4.3 W/SF 35°F walk-in cooler: 0.9 W/SF - 5°F walk-in freezer: 0.9 W/SF
Equipment power density	Sales: 1.15 W/SF Office: 1.73 W/SF Storage: 0.23 W/SF 50°F prep area: 0.23 W/SF + 36 kBTU/h process load 35°F walk-in cooler: 0.23 W/SF + 17 kBTU/h process load - 5°F walk-in freezer: 0.23 W/SF+ 29 kBTU/h process load
Operating hours	Mon-Sun: 6am – 10pm
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	Low temperature (-20°F suction temp): 23 compressor ton Medium temperature (18°F suction temp): 45 compressor ton
Refrigeration condenser size	Low temperature: 535 kBTU/h THR Medium temperature: 756 kBTU/h THR
Thermostat set points	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

A computer-generated sketch of the Grocery Building prototype is shown below.



High School

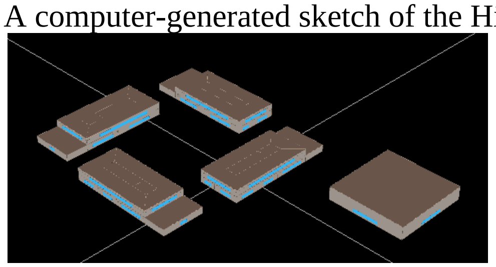
[782] DOE-2.2R is a specialized version of the DOE-2.2 program, designed specifically to model refrigeration systems.

A prototypical building energy simulation model for a high school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of four identical buildings oriented in four different directions, with a common gymnasium. The characteristics of the prototype are summarized below.

HIGH SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 88,200 SF Computer room: 3082 SF Dining area: 22,500 SF Gymnasium: 22.500 SF Kitchen: 10,500 SF Office: 3218 SF Total: 150,000 SF
Number of floors	2
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the High School Building prototype is shown below.



Hospital

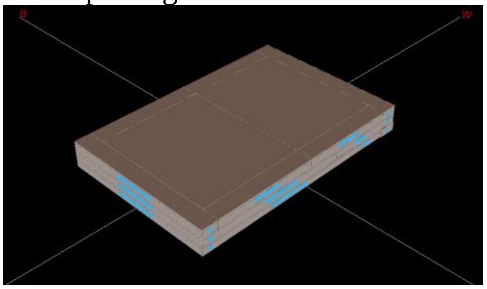
A prototypical building energy simulation model for a large hospital building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LARGE HOSPITAL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	250,000 square feet
Number of floors	3
Wall construction and R-value	Brick and CMU, R=7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Patient rooms: 2.3 W/SF Office: 2.2 W/SF Lab: 4.4 Dining: 1.7 Kitchen and food prep: 4.3
Plug load density	Patient rooms: 1.7 W/SF Office: 1.7 W/SF Lab: 1.7 Dining: 0.6 Kitchen and food prep: 4.6
Operating hours	24/7, 365
HVAC system types	Patient Rooms: 4 pipe fan coil Kitchen: Rooftop DX Remaining space; 1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 ºF set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 ºF set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Hospital Building prototype is shown below.



Hotel

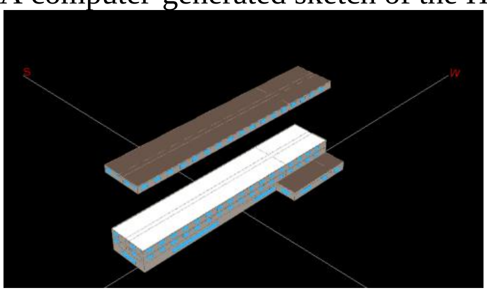
A prototypical building energy simulation model for a hotel building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

HOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	200,000 square feet total Bar, cocktail lounge – 800 SF Corridor – 20,100 SF Dining Area – 1,250 SF Guest rooms – 160,680 SF Kitchen – 750 SF Laundry – 4,100 SF Lobby – 8,220 Office – 4,100 SF
Number of floors	11
Wall construction and R-value	Block construction, R-7.5
Roof construction and R-value	Wood deck with built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Bar, cocktail lounge – 1.7 W/SF Corridor – 1.0 W/SF Dining Area – 1.7 W/SF Guest rooms – 0.6 W/SF Kitchen – 4.3 W/SF Laundry – 1.8 W/SF Lobby – 3.1 W/SF Office – 2.2 W/SF
Plug load density	Bar, cocktail lounge – 1.2 W/SF Corridor – 0.2 W/SF Dining Area – 0.6 W/SF Guest rooms – 0.6 W/SF Kitchen – 3.0 W/SF Laundry – 3.5 W/SF Lobby – 0.6 W/SF Office – 1.7 W/SF
Operating hours	Rooms: 60% occupied 40% unoccupied All others: 24 hr / day
HVAC system type	Central built-up system: All except corridors and rooms

Characteristic	Value
	1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer PTAC (Packaged Terminal Air Conditioner): Guest rooms PSZ: Corridors
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Minimum outdoor air fraction	Built up system 0.3; PSZ: 0.14; PTAC: 0.11 is typical.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Hotel Building prototype is shown below.



Large Office

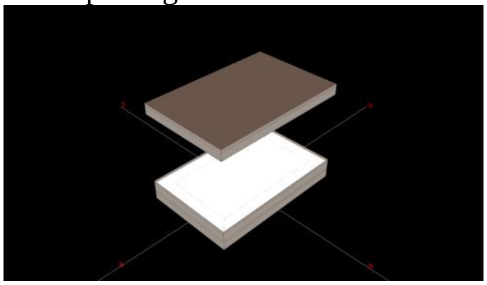
A prototypical building energy simulation model for a large office building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LARGE OFFICE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	350,000 square feet
Number of floors	10
Wall construction and R-value	Glass curtain wall, R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 W/SF Core offices: 1.45 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point
Thermostat set points	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 78 cooling, 67 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Office Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and the results are multiplied by 8 to represent the energy consumption of the eight middle floors.

Large Retail

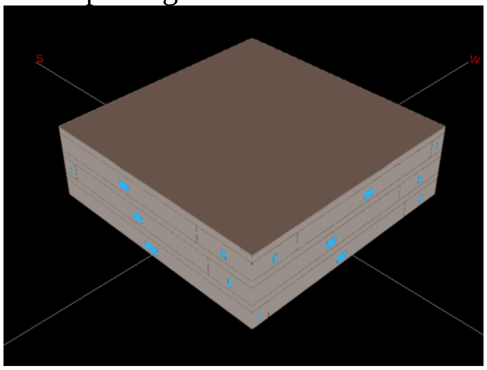
A prototypical building energy simulation model for a large retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LARGE RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	**Existing (1970s) vintage**
Size	130,000 square feet Sales area: 96,000 SF Storage: 18,000 SF Office: 6,000 SF
Number of floors	3
Wall construction and R-value	Brick and CMU with R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; SHGC= 0.73 U-value = 0.72
Lighting power density	Sales area: 2.8 W/SF Storage: 0.8 W/SF Office: 1.8 W/SF
Plug load density	Sales area: 1.1 W/SF Storage: 0.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sat: 9am – 10pm Sun: 9am – 7pm
HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	340 SF/ton
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Retail Building prototype is shown below.



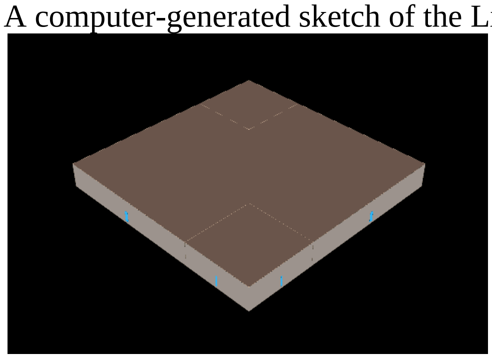
Light Industrial

A prototypical building energy simulation model for a light industrial building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LIGHT INDUSTRIAL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total 80,000 SF factory 20,000 SF warehouse
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Factory – 2.1 W/SF Warehouse – 0.9 W/SF
Plug load density	Factory – 1.2 W/SF Warehouse – 0.2 W/SF
Operating hours	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	500 - 560 SF/ton depending on climate
Thermostat set points	Occupied hours: 78 cooling, 70 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Light Industrial Building prototype is shown below.



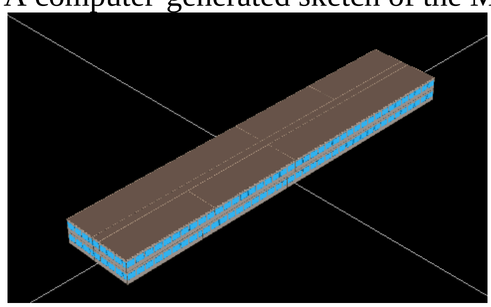
Motel

A prototypical building energy simulation model for a motel was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

MOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	30,000 square feet
Number of floors	2
Wall construction and R-value	Frame with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	0.6 W/SF
Plug load density	0.6 W/SF
Operating hours	24/7 - 365
HVAC system type	PTAC with electric heat
HVAC system size	540 SF/ton
Thermostat set points	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

A computer-generated sketch of the Motel Building prototype is shown below.



Refrigerated Warehouse

A prototypical building energy simulation model for a refrigerated warehouse building was developed using the DOE-2.2R[783] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

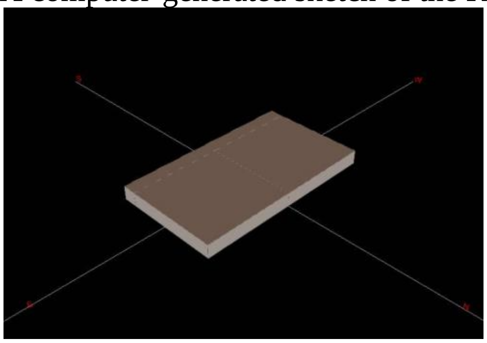
PROTOTYPICAL REFRIGERATED WAREHOUSE MODEL DESCRIPTION

Characteristic	Value
Vintage	New construction
Shape	Rectangular (400 ft by 230 ft)
Floor area	Freezer: 40,000 SF Cooler: 40,000 SF Shipping Dock: 12,000 SF Total: 92,000 SF

[783] DOE-2.2R is a specialized version of the DOE-2.2 program, designed specifically to model refrigeration systems.

Characteristic	Value
Number of floors	1
Floor to ceiling height	30 ft
Exterior wall construction	Insulated metal panel
Ext wall R-Value	Cooler and loading dock – R-20; Freezer – R-26

A computer-generated sketch of the Refrigerated Warehouse Building prototype is shown below.



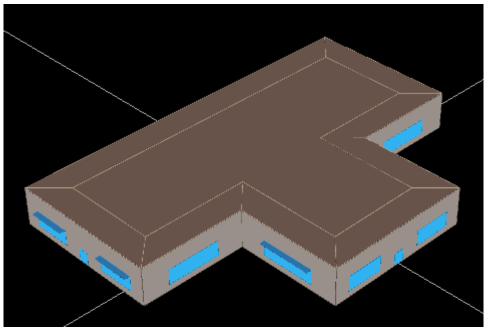
Religious

A prototypical building energy simulation model for a religious worship building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

RELIGIOUS WORSHIP PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	11,000 square feet
Number of floors	1
Wall construction and R-value	Brick with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	1.7 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sat: 12pm-6pm Sun: 9am – 7pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 70 heating Unoccupied hours: 82 cooling, 64 heating

A computer-generated sketch of the Religious Building prototype is shown below.



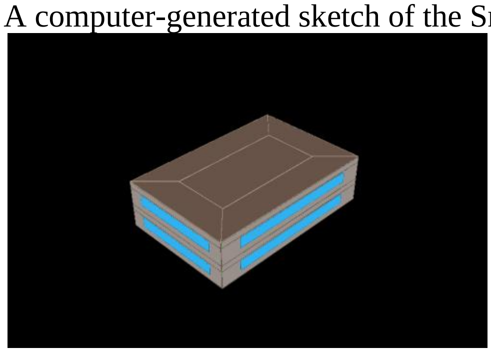
Small Office

A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small office prototype are summarized below.

SMALL OFFICE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	**Existing (1970s) vintage**
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Perimeter offices: 2.2 W/SF Core offices: 1.5 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 245 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Small Office Building prototype is shown below.



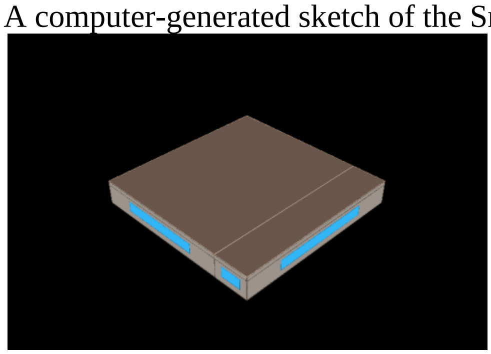
Small Retail

A prototypical building energy simulation model for a small retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small retail building prototype are summarized below.

SMALL RETAIL PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	6400 square foot sales area 1600 square foot storage area 8000 square feet total
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales area: 3.4 W/SF Storage area: 0.9 W/SF
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	10 – 10 Monday-Saturday 10 – 8 Sunday
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 – 250 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Small Retail Building prototype is shown below.



University

A prototypical building energy simulation model for a university building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really four identical buildings oriented 90 degrees apart. The characteristics of the prototype are summarized below.

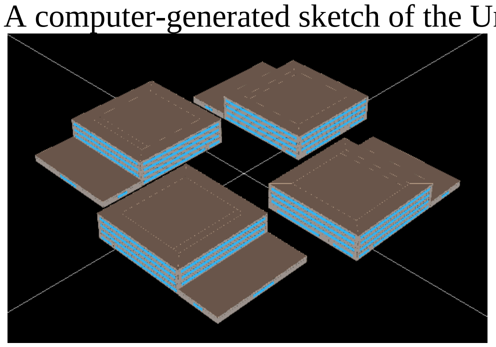
UNIVERSITY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 200,000 square feet each; oriented 90° from each other Classroom: 431,160 SF Computer room: 27,540 SF

Characteristic	Value
	Dining area: 24,000 SF Kitchen: 10,500 SF Office: 226,800 SF Total: 800,000 SF
Number of floors	4
Wall construction and R-value	Insulated frame wall with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Office: 2.0 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Office: 1.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 10pm Sat: 8am – 7pm Sun: closed
HVAC system type	Combination PSZ and built-up with centrifugal chiller and hot water boiler.
HVAC system size	400 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the University Building prototype is shown below.



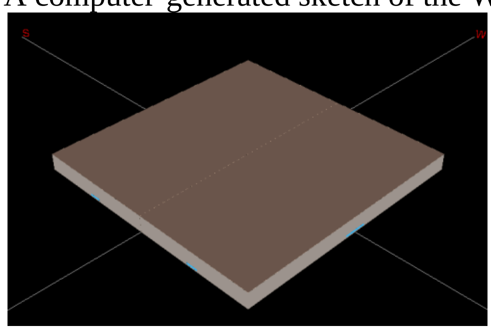
Warehouse

A prototypical building energy simulation model for a warehouse building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

WAREHOUSE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	500,000
Number of floors	1
Wall construction and insulation R-value	Concrete block, R-5
Roof construction and insulation R-value	Wood deck with built-up roof, R-12
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	0.9 W/SF
Plug load density	0.2 W/SF
Operating hours	Mon-Fri: 7am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Thermostat set points	Occupied hours: 80 cooling, 68 heating Unoccupied hours: 85 cooling, 63 heating

A computer-generated sketch of the Warehouse Building prototype is shown below.



Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-1	7/31/2013
7-13-18	7/31/2013
7-13-19	7/31/2013
7-13-21	7/31/2013
3-14-1	3/17/2014

APPENDIX B

HVAC WEIGHTING FACTORS

As described in the data sources and default value tables, it is permissible to use weighted average values across HVAC system types and building vintages when measure specific data are not available. Program administrators shall submit weighting factors used in their calculations for review and approval by the DPS. The weighting factors presented in this section may be used in lieu of program-specific weighting factors until such data are available.

Weighting factors developed for this section were taken from survey data compiled by the US Energy Information Agency (EIA), as part of the 2005 Residential Energy Consumption Survey (RECS) and the 2003 Commercial Building Energy Consumption Survey (CBECS). RECS survey data were collected specifically for New York state; CBECS data were collected for census division 2 (Middle Atlantic), which includes New York, New Jersey, and Pennsylvania.

SINGLE-FAMILY RESIDENTIAL BUILDING CALCULATIONS

The fractions of total building floor space for the Old and Average vintages are shown below. These data are compiled for building total (conditioned and unconditioned), heated and cooled floor space.

Vintage Weights for Single-family Detached Residential Buildings

	Total	Heated	Cooled
Old	0.441	0.420	0.358
Average	0.559	0.580	0.642

For example, approximately 64% of the cooled floor space is in buildings within the Average vintage, while 36% of the cooled floor space is in the Old vintage. Note, the RECS data did not provide information for new construction. Weighting calculations involving cooling savings should use the cooled floor space weights, while weighting calculations involving heating savings should use the heated floor space weights. Within each building vintage category, the weights by HVAC system type are shown below.

System Type Weights by Vintage for Single-family Detached Residential Buildings

System Type	Old	Average
AC with gas heat	0.474	0.616
Heat Pump	0.000	0.049
AC with electric heat	0.002	0.013
Electric heat only	0.004	0.017
Gas heat only	0.519	0.306
Room AC	0.629	0.371

MULTI-FAMILY RESIDENTIAL BUILDING CALCULATIONS

The fractions of total multi-family low-rise building floor space for the Old and Average vintage are shown below. These data are compiled for building total (conditioned and unconditioned), heated and cooled floor space. Low-rise buildings were identified as buildings with 2-4 units; or 1 or 2 story buildings with 5 or more units.

Vintage Weights for Low-rise Multi-family Residential Buildings

	Total	Heated	Cooled
Old	0.097	0.089	0.134
Average	0.903	0.911	0.866

The fractions of total multi-family high-rise building floor space for the Old and Average vintage are shown below. These data are compiled for building total (conditioned and unconditioned), heated and cooled floor space. High-rise buildings were identified as buildings with 3 or more stories.

Vintage Weights for High-rise Multi-family Residential Buildings

	Total	Heated	Cooled
Old	0.827	0.828	0.712
Average	0.173	0.172	0.288

Note, the RECS data did not provide information for new construction. Weighting calculations involving cooling savings should use the cooled floor space weights, while weighting calculations involving heating savings should use the heated floor space weights. For low-rise building calculations, weights by HVAC system type have been compiled. Within each building vintage category, the weights by HVAC system type are shown below.

HVAC System Type	Old	Average
AC with gas heat	0.542	0.350
Heat Pump	0.000	0.000
AC with electric heat	0.000	0.000
Electric heat only	0.006	0.012
Gas heat only	0.450	0.627
PTAC	0.003	0.012
PTHP	0.000	0.000

Note: The TRM assumes a single HVAC system type for high-rise buildings, thus weighting across HVAC system types is not required.

COMMERCIAL BUILDING CALCULATIONS

Weighting Factors for Commercial Building Calculations

The TRM currently lists energy savings estimates for small commercial buildings for a single vintage and HVAC system type, with the exception of HVAC interactive effects multipliers. Use the weights in the table below for HVAC interactive effects:

System Type Weights for Built-Up HVAC Systems from CBECS

Building Type	AC with gas heat	Heat Pump	AC with electric heat	Electric heat only	Gas heat only
Assembly	0.63	0.08	0.12	0.03	0.14
Auto Repair	0.54	0.08	0.10	0.04	0.24
Big Box	0.66	0.07	0.18	0.02	0.07
Elementary School	0.68	0.11	0.11	0.01	0.08
Fast Food	0.67	0.09	0.18	0.01	0.06
Full Service	0.67	0.09	0.18	0.01	0.06
Grocery	0.66	0.07	0.18	0.02	0.07
Light Industrial	0.46	0.06	0.00	0.10	0.37
Motel	0.46	0.23	0.26	0.02	0.03
Religious	0.57	0.11	0.13	0.03	0.15
Small Office	0.69	0.10	0.19	0.00	0.02
Small Retail	0.66	0.07	0.18	0.02	0.07
Warehouse	0.46	0.06	0.00	0.10	0.37
Other	0.60	0.10	0.14	0.03	0.13

(Note: Some types do not add up to exactly 1.00 due to rounding.)

Savings estimates for large commercial buildings are developed for several HVAC system and chiller type combinations. The CBECS data were analyzed to develop system type weights for these building types. The weighting factors for each of the two HVAC system types constant volume reheat (CV) and variable air volume (VAV) are shown below.

System Type Weights for Built-Up HVAC Systems from CBECS

System Type	Building					
	Hospital	Office	Education	Lodging	Retail	Other
CV	0.16	0.14	0.31	1.00	0.16	0.35
VAV	0.84	0.86	0.69	0.00	0.84	0.65

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-22	7/31/2013
9-13-3	9/27/2013

Appendix C

s a cross reference, the Effective Useful life (in hours) used for some lighting products, including LEDs, may be found in Appendix P which relies upon estimates established by the Design Lights Consortium and ENERGY STAR®.[784]

Standard Fixture Watts [785]

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
Compact Fluorescent Fixtures						
(Hard-wired or Pin-based only)						
CF10/2D	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	Mag-STD	1	10	16
CF10/2D-L	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	Electronic	1	10	12
CF11/1	CF11W	Compact Fluorescent, (1) 11W lamp	Mag-STD	1	11	13
CF11/2	CF11W	Compact Fluorescent, (2) 11W lamp	Mag-STD	2	11	26
CF16/2D	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	Mag-STD	1	16	26
CF16/2D-L	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	Electronic	1	16	18
CF18/3-L	CF18W	Compact Fluorescent, (3) 18W lamp	Electronic	3	18	60
CF21/2D	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	Mag-STD	1	21	26
CF21/2D-L	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	Electronic	1	21	22
CF23/1	CF23W	Compact Fluorescent, (1) 23W lamp	Mag-STD	1	23	29
CF23/1-L	CF23W	Compact Fluorescent, (1) 23W lamp	Electronic	1	23	25
CF26/3-L	CF26W	Compact Fluorescent, (3) 26W lamp	Electronic	3	26	82
CF26/4-L	CF26W	Compact Fluorescent, (4) 26W lamp	Electronic	4	26	108
CF26/6-L	CF26W	Compact Fluorescent, (6) 26W lamp	Electronic	6	26	162
CF26/8-L	CF26W	Compact Fluorescent, (8) 26W lamp	Electronic	8	26	216
CF28/2D	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	Mag-STD	1	28	35
CF28/2D-L	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	Electronic	1	28	28
CF32/3-L	CF32W	Compact Fluorescent, (3) 32W lamp	Electronic	3	32	114
CF32/4-L	CF32W	Compact Fluorescent, (4) 32W lamp	Electronic	4	32	152
CF32/6-L	CF32W	Compact Fluorescent, (6) 32W lamp	Electronic	6	32	228
CF32/8-L	CF32W	Compact Fluorescent, (8) 32W lamp	Electronic	8	32	304

[784] Some of the EULs of LED lighting products are based on the listing found in the Qualified Products List by the Design Light Consortium (DLC) at 35,000 or 50,000 hours, according to the appropriate Application Category as specified in the DLC"s *Product Qualification Criteria, Technical Requirement Table* version 2.0 or higher. The EUL of other LED products are based on the listing found in *the ENERGY STAR® Qualified Fixture List*, according to the appropriate luminaire classification as specified in the *ENERGY STAR®Program requirements for Luminaires*, version 1.2. The total hours are divided by estimated annual use, but capped at 15 years regardless (consistent with C&I redecoration and business type change patterns.)

[785] (Reference: NYSERDA Existing Buildings Lighting Table with Circline Additions from CA SPC Table)

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CF38/2D	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Mag-STD	1	38	46
CF38/2D-L	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Electronic	1	38	36
CF42/1-L	CF42W	Compact Fluorescent, (1) 42W lamp	Electronic	1	42	48
CF42/2-L	CF42W	Compact Fluorescent, (2) 42W lamp	Electronic	2	42	100
CF42/3-L	CF42W	Compact Fluorescent, (3) 42W lamp	Electronic	3	42	141
CF42/4-L	CF42W	Compact Fluorescent, (4) 42W lamp	Electronic	4	42	188
CF42/6-L	CF42W	Compact Fluorescent, (6) 42W lamp	Electronic	6	42	282
CF42/8-L	CF42W	Compact Fluorescent, (8) 42W lamp	Electronic	8	42	376
CFQ10/1	CFQ10W	Compact Fluorescent, quad, (1) 10W lamp	Mag-STD	1	10	15
CFQ13/1	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp	Mag-STD	1	13	17
CFQ13/1-L	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp, BF=1.05	Electronic	1	13	15
CFQ13/2	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp	Mag-STD	2	13	31
CFQ13/2-L	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp, BF=1.0	Electronic	2	13	28
CFQ13/3	CFQ13W	Compact Fluorescent, quad, (3) 13W lamp	Mag-STD	3	13	48
CFQ15/1	CFQ15W	Compact Fluorescent, quad, (1) 15W lamp	Mag-STD	1	15	20
CFQ17/1	CFQ17W	Compact Fluorescent, quad, (1) 17W lamp	Mag-STD	1	17	24
CFQ17/2	CFQ17W	Compact Fluorescent, quad, (2) 17W lamp	Mag-STD	2	17	48
CFQ18/1	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp	Mag-STD	1	18	26
CFQ18/1-L	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp, BF=1.0	Electronic	1	18	20
CFQ18/2	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp	Mag-STD	2	18	45
CFQ18/2-L	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp, BF=1.0	Electronic	2	18	38
CFQ18/4	CFQ18W	Compact Fluorescent, quad, (4) 18W lamp	Mag-STD	2	18	90
CFQ20/1	CFQ20W	Compact Fluorescent, quad, (1) 20W lamp	Mag-STD	1	20	23
CFQ20/2	CFQ20W	Compact Fluorescent, quad, (2) 20W lamp	Mag-STD	2	20	46
CFQ22/1	CFQ22W	Compact Fluorescent, quad, (1) 22W lamp	Mag-STD	1	22	24
CFQ22/2	CFQ22W	Compact Fluorescent, quad, (2) 22W lamp	Mag-STD	2	22	48
CFQ22/3	CFQ22W	Compact Fluorescent, quad, (3) 22W lamp	Mag-STD	3	22	72
CFQ25/1	CFQ25W	Compact Fluorescent, quad, (1) 25W lamp	Mag-STD	1	25	33
CFQ25/2	CFQ25W	Compact Fluorescent, quad, (2) 25W lamp	Mag-STD	2	25	66
CFQ26/1	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp	Mag-STD	1	26	33
CFQ26/1-L	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp, BF=0.95	Electronic	1	26	27
CFQ26/2	CFQ26W	Compact Fluorescent, quad, (2) 26W lamp	Mag-STD	2	26	66

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFQ26/2-L	CFQ26W	Compact Fluorescent, quad, (2) 26W lamp, BF=0.95	Electronic	2	26	50
CFQ26/3	CFQ26W	Compact Fluorescent, quad, (3) 26W lamp	Mag-STD	3	26	99
CFQ26/6-L	CFQ26W	Compact Fluorescent, quad, (6) 26W lamp, BF=0.95	Electronic	6	26	150
CFQ28/1	CFQ28W	Compact Fluorescent, quad, (1) 28W lamp	Mag-STD	1	28	33
CFQ9/1	CFQ9W	Compact Fluorescent, quad, (1) 9W lamp	Mag-STD	1	9	14
CFQ9/2	CFQ9W	Compact Fluorescent, quad, (2) 9W lamp	Mag-STD	2	9	23
CFS7/1	CFS7W	Compact Fluorescent, spiral, (1) 7W lamp	Electronic	1	7	7
CFS9/1	CFS9W	Compact Fluorescent, spiral, (1) 9W lamp	Electronic	1	9	9
CFS11/1	CFS11W	Compact Fluorescent, spiral, (1) 11W lamp	Electronic	1	11	11
CFS15/1	CFS15W	Compact Fluorescent, spiral, (1) 15W lamp	Electronic	1	15	15
CFS20/1	CFS20W	Compact Fluorescent, spiral, (1) 20W lamp	Electronic	1	20	20
CFS23/1	CFS23W	Compact Fluorescent, spiral, (1) 23W lamp	Electronic	1	23	23
CFS27/1	CFS27W	Compact Fluorescent, spiral, (1) 27W lamp	Electronic	1	27	27
CFT13/1	CFT13W	Compact Fluorescent, twin, (1) 13W lamp	Mag-STD	1	13	17
CFT13/2	CFT13W	Compact Fluorescent, twin, (2) 13W lamp	Mag-STD	2	13	31
CFT13/3	CFT13W	Compact Fluorescent, twin, (3) 13 W lamp	Mag-STD	3	13	48
CFT18/1	CFT18W	Compact Fluorescent, long twin., (1) 18W lamp	Mag-STD	1	18	24
CFT22/1	CFT22W	Compact Fluorescent, twin, (1) 22W lamp	Mag-STD	1	22	27
CFT22/2	CFT22W	Compact Fluorescent, twin, (2) 22W lamp	Mag-STD	2	22	54
CFT22/4	CFT22W	Compact Fluorescent, twin, (4) 22W lamp	Mag-STD	4	22	108
CFT24/1	CFT24W	Compact Fluorescent, long twin, (1) 24W lamp	Mag-STD	1	24	32
CFT28/1	CFT28W	Compact Fluorescent, twin, (1) 28W lamp	Mag-STD	1	28	33
CFT28/2	CFT28W	Compact Fluorescent, twin, (2) 28W lamp	Mag-STD	2	28	66
CFT32/1-L	CFM32W	Compact Fluorescent, twin or multi, (1) 32W lamp	Electronic	1	32	34
CFT32/2-L	CFM32W	Compact Fluorescent, twin or multi, (2) 32W lamp	Electronic	2	32	62
CFT32/6-L	CFM32W	Compact Fluorescent, twin or multi, (2) 32W lamp	Electronic	6	32	186
CFT36/1	CFT36W	Compact Fluorescent, long twin, (1) 36W lamp	Mag-STD	1	36	51
CFT36/4-BX	CFT36W	Compact Fluorescent, Biax, (4) 36W lamp	Electronic	4	36	148
CFT36/6-BX	CFT36W	Compact Fluorescent, Biax, (6) 36W lamp	Electronic	6	36	212
CFT36/6-L	CFT36W	Compact Fluorescent, long Twin, (6) 36W lamp	Electronic	6	36	198

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFT36/6-L	CFT36W	Compact Fluorescent, long Twin, (6) 36W lamp/ High Ballast Factor	Electronic	6	36	210
CFT36/8-BX	CFT36W	Compact Fluorescent, Biax, (8) 36W lamp	Electronic	8	36	296
CFT36/8-L	CFT36W	Compact Fluorescent, long Twin, (8) 36W lamp	Electronic	8	36	270
CFT36/8-L	CFT36W	Compact Fluorescent, long Twin, (8) 36W lamp/ High Ballast Factor	Electronic	8	36	286
CFT36/9-BX	CFT36W	Compact Fluorescent, Biax, (9) 36W lamp	Electronic	9	36	318
CFT40/1	CFT40W	Compact Fluorescent, twin, (1) 40W lamp	Mag-STD	1	40	46
CFT40/12-BX	CFT40W	Compact Fluorescent, Biax, (12) 40W lamp	Electronic	12	40	408
CFT40/1-BX	CFT40W	Compact Fluorescent, Biax, (1) 40W lamp	Electronic	1	40	46
CFT40/1-L	CFT40W	Compact Fluorescent, long twin, (1) 40W lamp	Electronic	1	40	43
CFT40/2	CFT40W	Compact Fluorescent, twin, (2) 40W lamp	Mag-STD	2	40	85
CFT40/2-BX	CFT40W	Compact Fluorescent, Biax, (2) 40W lamp	Electronic	2	40	72
CFT40/2-L	CFT40W	Compact Fluorescent, long twin, (2) 40W lamp	Electronic	2	40	72
CFT40/3	CFT40W	Compact Fluorescent, twin, (3) 40 W lamp	Mag-STD	3	40	133
CFT40/3-BX	CFT40W	Compact Fluorescent, Biax, (3) 40W lamp	Electronic	3	40	102
CFT40/3-L	CFT40W	Compact Fluorescent, long twin, (3) 40W lamp	Electronic	3	40	105
CFT40/4-BX	CFT40W	Compact Fluorescent, Biax, (4) 40W lamp	Electronic	4	40	144
CFT40/5-BX	CFT40W	Compact Fluorescent, Biax, (5) 40W lamp	Electronic	5	40	190
CFT40/6-BX	CFT40W	Compact Fluorescent, Biax, (6) 40W lamp	Electronic	6	40	204
CFT40/6-L	CFT40W	Compact Fluorescent, long Twin, (6) 40W lamp	Electronic	6	40	220
CFT40/6-L	CFT40W	Compact Fluorescent, long Twin, (6) 40W lamp/ High Ballast Factor	Electronic	6	40	233
CFT40/8-BX	CFT40W	Compact Fluorescent, Biax, (8) 40W lamp	Electronic	8	40	288
CFT40/8-L	CFT40W	Compact Fluorescent, long Twin, (8) 40W lamp	Electronic	8	40	300
CFT40/8-L	CFT40W	Compact Fluorescent, long Twin, (8) 40W lamp/ High Ballast Factor	Electronic	8	40	340
CFT40/9-BX	CFT40W	Compact Fluorescent, Biax, (9) 40W lamp	Electronic	9	40	306
CFT5/1	CFT5W	Compact Fluorescent, twin, (1) 5W lamp	Mag-STD	1	5	9
CFT5/2	CFT5W	Compact Fluorescent, twin, (2) 5W lamp	Mag-STD	2	5	18
CFT50/12-BX	CFT50W	Compact Fluorescent, Biax, (12) 50W lamp	Electronic	12	50	648
CFT50/1-BX	CFT50W	Compact Fluorescent, Biax, (1) 50W lamp	Electronic	1	50	54
CFT50/2-BX	CFT50W	Compact Fluorescent, Biax, (2) 50W lamp	Electronic	2	50	108
CFT50/3-BX	CFT50W	Compact Fluorescent, Biax, (3) 50W lamp	Electronic	3	50	162

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFT50/4-BX	CFT50W	Compact Fluorescent, Biax, (4) 50W lamp	Electronic	4	50	216
CFT50/5-BX	CFT50W	Compact Fluorescent, Biax, (5) 50W lamp	Electronic	5	50	270
CFT50/6-BX	CFT50W	Compact Fluorescent, Biax, (6) 50W lamp	Electronic	6	50	324
CFT50/8-BX	CFT50W	Compact Fluorescent, Biax, (8) 50W lamp	Electronic	8	50	432
CFT50/9-BX	CFT50W	Compact Fluorescent, Biax, (9) 50W lamp	Electronic	9	50	486
CFT55/12-BX	CFT55W	Compact Fluorescent, Biax, (12) 55W lamp	Electronic	12	55	672
CFT55/1-BX	CFT55W	Compact Fluorescent, Biax, (1) 55W lamp	Electronic	1	55	56
CFT55/2-BX	CFT55W	Compact Fluorescent, Biax, (2) 55W lamp	Electronic	2	55	112
CFT55/3-BX	CFT55W	Compact Fluorescent, Biax, (3) 55W lamp	Electronic	3	55	168
CFT55/4-BX	CFT55W	Compact Fluorescent, Biax, (4) 55W lamp	Electronic	4	55	224
CFT55/5-BX	CFT55W	Compact Fluorescent, Biax, (5) 55W lamp	Electronic	5	55	280
CFT55/6-BX	CFT55W	Compact Fluorescent, Biax, (6) 55W lamp	Electronic	6	55	336
CFT55/6-L	CFT55W	Compact Fluorescent, long Twin, (6) 55W lamp	Electronic	6	55	352
CFT55/6-L	CFT55W	Compact Fluorescent, long Twin, (6) 55W lamp/ High Ballast Factor	Electronic	6	55	373
CFT55/8-BX	CFT55W	Compact Fluorescent, Biax, (8) 55W lamp	Electronic	8	55	448
CFT55/8-L	CFT55W	Compact Fluorescent, long Twin, (8) 55W lamp	Electronic	8	55	468
CFT55/8-L	CFT55W	Compact Fluorescent, long Twin, (8) 55W lamp/ High Ballast Factor	Electronic	8	55	496
CFT55/9-BX	CFT55W	Compact Fluorescent, Biax, (9) 55W lamp	Electronic	9	55	504
CFT7/1	CFT7W	Compact Fluorescent, twin, (1) 7W lamp	Mag-STD	1	7	10
CFT7/2	CFT7W	Compact Fluorescent, twin, (2) 7W lamp	Mag-STD	2	7	21
CFT9/1	CFT9W	Compact Fluorescent, twin, (1) 9W lamp	Mag-STD	1	9	11
CFT9/2	CFT9W	Compact Fluorescent, twin, (2) 9W lamp	Mag-STD	2	9	23
CFT9/3	CFT9W	Compact Fluorescent, twin, (3) 9W lamp	Mag-STD	3	9	34
EXIT SIGN FIXTURES						
ECF5/1	CFT5W	EXIT Compact Fluorescent, (1) 5W lamp	Mag-STD	1	5	9
ECF5/2	CFT5W	EXIT Compact Fluorescent, (2) 5W lamp	Mag-STD	2	5	20
ECF7/1	CFT7W	EXIT Compact Fluorescent, (1) 7W lamp	Mag-STD	1	7	10
ECF7/2	CFT7W	EXIT Compact Fluorescent, (2) 7W lamp	Mag-STD	2	7	21
ECF8/1	F8T5	EXIT T5 Fluorescent, (1) 8W lamp	Mag-STD	1	8	12
ECF8/2	F8T5	EXIT T5 Fluorescent, (2) 8W lamp	Mag-STD	2	8	24
ECF9/1	CFT9W	EXIT Compact Fluorescent, (1) 9W lamp	Mag-STD	1	9	12
ECF9/2	CFT9W	EXIT Compact Fluorescent, (2) 9W lamp	Mag-STD	2	9	20

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
EI10/2	I10	EXIT Incandescent, (2) 10W lamp		2	10	20
EI15/1	I15	EXIT Incandescent, (1) 15W lamp		1	15	15
EI15/2	I15	EXIT Incandescent, (2) 15W lamp		2	15	30
EI20/1	I20	EXIT Incandescent, (1) 20W lamp		1	20	20
EI20/2	I20	EXIT Incandescent, (2) 20W lamp		2	20	40
EI25/1	I25	EXIT Incandescent, (1) 25W lamp		1	25	25
EI25/2	I25	EXIT Incandescent, (2) 25W lamp		2	25	50
EI34/1	I34	EXIT Incandescent, (1) 34W lamp		1	34	34
EI34/2	I34	EXIT Incandescent, (2) 34W lamp		2	34	68
EI40/1	I40	EXIT Incandescent, (1) 40W lamp		1	40	40
EI40/2	I40	EXIT Incandescent, (2) 40W lamp		2	40	80
EI5/1	I5	EXIT Incandescent, (1) 5W lamp		1	5	5
EI5/2	I5	EXIT Incandescent, (2) 5W lamp		2	5	10
EI50/2	I50	EXIT Incandescent, (2) 50W lamp		2	50	100
EI7.5/1	I7.5	EXIT Tungsten, (1) 7.5 W lamp		1	7.5	8
EI7.5/2	I7.5	EXIT Tungsten, (2) 7.5 W lamp		2	7.5	15
ELED0.5/1	LED0.5W	EXIT Light Emitting Diode, (1) 0.5W lamp, Single Sided		1	0.5	0.5
ELED0.5/2	LED0.5W	EXIT Light Emitting Diode, (2) 0.5W lamp, Dual Sided		2	0.5	1
ELED1.5/1	LED1.5W	EXIT Light Emitting Diode, (1) 1.5W lamp, Single Sided		1	1.5	1.5
ELED1.5/2	LED1.5W	EXIT Light Emitting Diode, (2) 1.5W lamp, Dual Sided		2	1.5	3
ELED10.5/1	LED10.5W	EXIT Light Emitting Diode, (1) 10.5W lamp, Single Sided		1	10.5	10.5
ELED10.5/2	LED10.5W	EXIT Light Emitting Diode, (2) 10.5W lamp, Dual Sided		2	10.5	21
ELED2/1	LED2W	EXIT Light Emitting Diode, (1) 2W lamp, Single Sided		1	2	2
ELED2/2	LED2W	EXIT Light Emitting Diode, (2) 2W lamp, Dual Sided		2	2	4
ELED3/1	LED3W	EXIT Light Emitting Diode, (1) 3W lamp, Single Sided		1	3	3
ELED3/2	LED3W	EXIT Light Emitting Diode, (2) 3W lamp, Dual Sided		2	3	6

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
ELED5/1	LED5W	EXIT Light Emitting Diode, (1) 5W lamp, Single Sided		1	5	5
ELED5/2	LED5W	EXIT Light Emitting Diode, (2) 5W lamp, Dual Sided		2	5	10
ELED8/1	LED8W	EXIT Light Emitting Diode, (1) 8W lamp, Single Sided		1	8	8
ELED8/2	LED8W	EXIT Light Emitting Diode, (2) 8W lamp, Dual Sided		2	8	16
LINEAR FLUORESCENT FIXTURES						
F1.51LS	F15T8	Fluorescent, (1) 18" T8 lamp	Mag-STD	1	15	19
F1.51SS	F15T12	Fluorescent, (1) 18" T12 lamp	Mag-STD	1	15	19
F1.52LS	F15T8	Fluorescent, (2) 18" T8 lamp	Mag-STD	2	15	36
F1.52SS	F15T12	Fluorescent, (2) 18", T12 lamp	Mag-STD	2	15	36
F21HS	F24T12/HO	Fluorescent, (1) 24", HO lamp	Mag-STD	1	35	62
F21ILL	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	20
F21ILL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	17	17
F21ILL/T2-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 2 Lamp Ballast	Electronic	1	17	15
F21ILL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	17	16
F21ILL/T3-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	17	14
F21ILL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	17	15
F21ILL/T4-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	17	14
F21ILX-R	F17T8	Fluorescent, (1) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	1	17	15

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F21ILX	F17T8	Fluorescent, (1) 24", T-8 lamp, HE Instant/Program Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	16
F21LL	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	16
F21LL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	17	16
F21LL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	17	17
F21LL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	17	17
F21LL-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	17	15
F21LS	F17T8	Fluorescent, (1) 24", T8 lamp, Standard Ballast	Mag-STD	1	17	24
F21GL	F24T5	Fluorescent, (1) 24", STD T5 lamp	Electronic	1	14	18
F21SE	F20T12	Fluorescent, (1) 24", STD lamp	Mag-ES	1	20	26
F21SS	F20T12	Fluorescent, (1) 24", STD lamp	Mag-STD	1	20	28
F21GHL	F24T5/HO	Fluorescent, (1) 24", STD HO T5 lamp	Electronic	1	24	29
F22SHS	F24T12/HO	Fluorescent, (2) 24", HO lamp	Mag-STD	2	35	90
F22GHL	F24T5/HO	Fluorescent, (2) 24", STD HO T5 lamp	Electronic	2	24	55
F22ILE	F17T8	Fluorescent, (2) 24", T-8 Instant Start lamp, Energy Saving Magnetic Ballast	Mag-ES	2	17	45
F22ILL	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	33
F22ILL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	31
F22ILL/T4-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	17	28
F22ILL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	17	29

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F22ILX-R	F17T8	Fluorescent, (2) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	2	17	27
F22ILX	F17T8	Fluorescent, (2) 24", T-8 lamp, HE Instant/Program Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	31
F22LL	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	31
F22LL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	34
F22LL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	17	28
F22GL	F24T5	Fluorescent, (2) 24", STD T5 lamp	Electronic	2	14	35
F22SE	F20T12	Fluorescent, (2) 24", STD lamp	Mag-ES	2	20	51
F22SS	F20T12	Fluorescent, (2) 24", STD lamp	Mag-STD	2	20	56
F23ILL	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	47
F23ILL-H	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	17	49
F23ILL-R	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	17	43
F23ILX	F17T8	Fluorescent, (3) 24", T-8 lamp, HE Instant/Program Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	45
F23ILX-R	F17T8	Fluorescent, (3) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	3	17	40
F23LL	F17T8	Fluorescent, (3) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	52
F23LL-R	F17T8	Fluorescent, (3) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	17	41
F23SE	F20T12	Fluorescent, (3) 24", STD lamp	Mag-ES	3	20	77
F23SS	F20T12	Fluorescent, (3) 24", STD lamp	Mag-STD	3	20	84
F24ILL	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	61
F24ILL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	17	55

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F24ILX-R	F17T8	Fluorescent, (4) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	4	17	53
F24LL	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	68
F24LL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	17	57
F24SE	F20T12	Fluorescent, (4) 24", STD lamp	Mag-ES	4	20	102
F24SS	F20T12	Fluorescent, (4) 24", STD lamp	Mag-STD	4	20	112
F26SE	F20T12	Fluorescent, (6) 24", STD lamp	Mag-ES	6	20	153
F26SS	F20T12	Fluorescent, (6) 24", STD lamp	Mag-STD	6	20	168
F31EE	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-ES	1	25	38
F31EE/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-ES	1	25	33
F31EL	F30T12/ES	Fluorescent, (1) 36", ES lamp	Electronic	1	25	26
F31ES	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-STD	1	25	42
F31ES/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-STD	1	25	37
F31ILL	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	26
F31ILL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31ILL/T2-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF: .96-1.1), Tandem 2 Lamp Ballast	Electronic	1	25	24
F31ILL/T2-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31ILL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	22
F31ILL/T3-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	25	22
F31ILL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	22

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F31ILL/T4-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	25	22
F31ILL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	25	28
F31ILL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	25	27
F31LL	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	24
F31LL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31LL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	24
F31LL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	22
F31LL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	1	25	26
F31LL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	25	23
F31ILX-R	F25T8	Fluorescent, (1) 36", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	1	25	21
F31SE/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-ES	1	30	37
F31GHL	F36T5/HO	Fluorescent, (1) 36", STD HO T5 lamp	Electronic	1	39	43
F31SHS	F36T12/HO	Fluorescent, (1) 36", HO lamp	Mag-STD	1	50	70
F31SL	F30T12	Fluorescent, (1) 36", STD lamp	Electronic	1	30	31
F31GL	F36T5	Fluorescent, (1) 36", STD T5 lamp	Electronic	1	21	27
F31SS	F30T12	Fluorescent, (1) 36", STD lamp	Mag-STD	1	30	46
F31SS/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-STD	1	30	41
F32EE	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-ES	2	25	66
F32EL	F30T12/ES	Fluorescent, (2) 36", ES lamp	Electronic	2	25	50
F32ES	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-STD	2	25	73
F32ILL	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	46

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F32ILL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	44
F32ILL/T4-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	25	43
F32ILL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	48
F32ILL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	25	46
F32ILX-R	F25T8	Fluorescent, (2) 36", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	2	25	39
F32LE	F25T8	Fluorescent, (2) 36", T-8 lamp	Mag-ES	2	25	65
F32LL	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	46
F32LL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	45
F32LL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	50
F32LL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	25	42
F32LL-V	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	25	70
F32SE	F30T12	Fluorescent, (2) 36", STD lamp	Mag-ES	2	30	74
F32GHL	F36T5/HO	Fluorescent, (1) 36", STD HO T5 lamp	Electronic	2	39	85
F32SHS	F36T12/HO	Fluorescent, (2) 36", HO, lamp	Mag-STD	2	50	114
F32SL	F30T12	Fluorescent, (2) 36", STD lamp	Electronic	2	30	58
F32GL	F36T5	Fluorescent, (1) 36", STD T5 lamp	Electronic	2	21	52
F32SS	F30T12	Fluorescent, (2) 36", STD lamp	Mag-STD	2	30	81
F33ES	F30T12/ES	Fluorescent, (3) 36", ES lamp	Mag-STD	3	25	115
F33ILL	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	67
F33ILL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	66
F33LL	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	72

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F33LL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	25	62
F33SE	F30T12	Fluorescent, (3) 36", STD lamp, (1) STD ballast and (1) ES ballast	Mag-ES	3	30	120
F33SS	F30T12	Fluorescent, (3) 36", STD lamp	Mag-STD	3	30	127
F34ILL	F25T8	Fluorescent, (4) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	25	87
F34ILL-R	F25T8	Fluorescent, (4) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	25	86
F34LL	F25T8	Fluorescent, (4) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	25	89
F34LL-R	F25T8	Fluorescent, (4) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	25	84
F34SE	F30T12	Fluorescent, (4) 36", STD lamp	Mag-ES	4	30	148
F34SL	F30T12	Fluorescent, (4) 36", STD lamp	Electronic	4	30	116
F34SS	F30T12	Fluorescent, (4) 36", STD lamp	Mag-STD	4	30	162
F36EE	F30T12/ES	Fluorescent, (6) 36", ES lamp	Mag-ES	6	25	198
F36ILL-R	F25T8	Fluorescent, (6) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85)	Electronic	6	25	134
F36SE	F30T12	Fluorescent, (6) 36", STD lamp	Mag-ES	6	30	238
F40EE/D1	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (1) hot ballast	Mag-ES	0	0	4
F40EE/D2	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (2) hot ballast	Mag-ES	0	0	8
F41EE	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-ES	1	34	43
F41EE/D2	F40T12/ES	Fluorescent, (1) 48", ES lamp, 2 ballast	Mag-ES	1	34	43
F41EE/T2	F40T12/ES	Fluorescent, (1) 48", ES lamp, tandem wired, 2-lamp ballast	Mag-ES	1	34	36
F41EHS	F48T12/HO/ES	Fluorescent, (1) 48", ES HO lamp	Mag-STD	1	55	80
F41EIS	F48T12/ES	Fluorescent, (1) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	1	30	51
F41EL	F40T12/ES	Fluorescent, (1) 48", T12 ES lamp, Electronic Ballast	Electronic	1	34	32
F41EL/T2	F40T12/ES	Fluorescent, (1) 48", T-12 ES lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	34	32
F41ES	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-STD	1	34	50

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41EVS	F48T12/VHO/ES	Fluorescent, (1) 48", VHO ES lamp	Mag-STD	1		123
F41IAL	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start Ballast	Electronic	1	25	25
F41IAL/T2-R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start, Tandem 2-Lamp Ballast, RLO (BF<0.85)	Electronic	1	25	19
F41IAL/T3-R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start, Tandem 3-Lamp Ballast, RLO (BF<0.85)	Electronic	1	25	20
F41ILL	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	31
F41SILL	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	30	28
F41SILL/T2	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	30	27
F41SILL/T3	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	30	27
F41SILL/T4	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	30	26
F41SILL-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	30	25
F41SILL/T2-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	30	24
F41SILL/T3-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	30	24
F41SILL/T4-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	30	23
F41SILL-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	30	37
F41SILL/T2-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	30	36

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41SILL/T3-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	30	36
F41SSILL	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	28	26
F41SSILL/T2	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	28	25
F41SSILL/T3	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	28	25
F41SSILL/T4	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	28	24
F41SSILL-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	28	23
F41SSILL/T2-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	28	22
F41SSILL/T3-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	28	22
F41SSILL/T4-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	28	21
F41SSILL-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	28	33
F41SSILL/T2-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	28	32
F41SSILL/T3-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	28	32
F41ILL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	30

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41ILL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	32	33
F41ILL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	26
F41ILL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	32	30
F41ILL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	32	31
F41ILL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	32	26
F41ILL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	32	28
F41ILL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	32	26
F41ILL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	36
F41ILX-H	F32T8	Fluorescent, (1) 48", T-8 lamp, HE Instant/Program Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	35
F41ILX-R	F32T8	Fluorescent, (1) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	1	32	25
F41LE	F32T8	Fluorescent, (1) 48", T-8 lamp	Mag-ES	1	32	35
F41LL	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	32
F41LL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	30
F41LL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	32	39
F41LL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	27

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41LL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	32	31
F41LL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	32	33
F41LL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	32	25
F41LL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	32	30
F41LL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	32	26
F41LL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	39
F41LL-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	32	27
F41SE	F40T12	Fluorescent, (1) 48", STD lamp	Mag-ES	1	40	50
F41GHL	F48T5/HO	Fluorescent, (1) 48", STD HO T5 lamp	Electronic	1	54	59
F41SHS	F48T12/HO	Fluorescent, (1) 48", STD HO lamp	Mag-STD	1	60	85
F41SIL	F48T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast	Electronic	1	39	46
F41SIL/T2	F48T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast, tandem wired	Electronic	1	39	37
F41SIS	F48T12	Fluorescent, (1) 48", STD IS lamp	Mag-STD	1	39	60
F41SIS/T2	F48T12	Fluorescent, (1) 48", STD IS lamp, tandem to 2-lamp ballast	Mag-STD	1	39	52
F41GL	F48T5	Fluorescent, (1) 48", STD T5 lamp	Electronic	1	28	32
F41SL/T2	F40T12	Fluorescent, (1) 48", T-12 STD lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	40	36
F41SS	F40T12	Fluorescent, (1) 48", STD lamp	Mag-STD	1	40	57
F41SVS	F48T12/VHO	Fluorescent, (1) 48", STD VHO lamp	Mag-STD	1	110	135
F41TS	F40T10	Fluorescent, (1) 48", T-10 lamp	Mag-STD	1	40	51
F42EE	F40T12/ES	Fluorescent, (2) 48", ES lamp	Mag-ES	2	34	72

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F42EE/D2	F40T12/ES	Fluorescent, (2) 48", ES lamp, 2 Ballasts (delamped)	Mag-ES	2	34	76
F42EHS	F48T12/HO/ES	Fluorescent, (2) 42", HO lamp (3.5' lamp)	Mag-STD	2	55	135
F42EIS	F48T12/ES	Fluorescent, (2) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	2	30	82
F42EL	F40T12/ES	Fluorescent, (2) 48", T12 ES lamps, Electronic Ballast	Electronic	2	34	60
F42ES	F40T12/ES	Fluorescent, (2) 48", ES lamp	Mag-STD	2	34	80
F42EVS	F48T12/VHO/ES	Fluorescent, (2) 48", VHO ES lamp	Mag-STD	2		210
F42IAL/T4-R	F25T12	Fluorescent, (2) 48", F25T12 lamp, Instant Start, Tandem 4-Lamp Ballast, RLO (BF<0.85)	Electronic	2	25	40
F42IAL-R	F25T12	Fluorescent, (2) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	25	39
F42ILL	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	59
F42SILL	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	30	53
F41SILL/T4	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	30	52
F42SILL-R	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	30	47
F41SILL/T4-R	F30T8	Fluorescent, (2) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	30	46
F42SILL-H	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-2.2)	Electronic	2	30	72
F42SSILL	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	28	48
F41SSILL/T4	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	28	47
F42SSILL-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	28	45
F41SSILL/T4-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	28	44

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F42SSILL-H	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-2.2)	Electronic	2	28	67
F42ILL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	56
F42ILL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	51
F42ILL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	65
F42ILL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	32	52
F42ILL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	2	32	79
F42ILX-H	F32T8	Fluorescent, (2) 48", T-8 lamp, HE Instant/Program Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	63
F42ILX-R	F32T8	Fluorescent, (2) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	2	32	48
F42ILX-V	F32T8	Fluorescent, (2) 48", T-8 lamp, HE Instant/Program Start Ballast, VHLO (BF>1.1)	Electronic	2	32	74
F42LE	F32T8	Fluorescent, (2) 48", T-8 lamp	Mag-ES	2	32	71
F42LL	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	60
F42LL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	59
F42LL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	53
F42LL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	70
F42LL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	32	54
F42LL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	32	85
F42SE	F40T12	Fluorescent, (2) 48", STD lamp	Mag-ES	2	40	86

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F42GHL	F48T5/HO	Fluorescent, (2) 48", STD HO T5 lamp	Electronic	2	54	117
F42SHS	F48T12/HO	Fluorescent, (2) 48", STD HO lamp	Mag-STD	2	60	145
F42SIL	F48T12	Fluorescent, (2) 48", STD IS lamp, Electronic ballast	Electronic	2	39	74
F42SIS	F48T12	Fluorescent, (2) 48", STD IS lamp	Mag-STD	2	39	103
F42GL	F48T5	Fluorescent, (2) 48", STD T5 lamp	Electronic	2	28	63
F42SS	F40T12	Fluorescent, (2) 48", STD lamp	Mag-STD	2	40	94
F42SVS	F48T12/VHO	Fluorescent, (2) 48", STD VHO lamp	Mag-STD	2	110	242
F43EE	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-ES	3	34	115
F43EHS	F48T12/HO/ES	Fluorescent, (3) 48", ES HO lamp (3.5' lamp)	Mag-STD	3	55	215
F43EIS	F48T12/ES	Fluorescent, (3) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	3	30	133
F43EL	F40T12/ES	Fluorescent, (3) 48", T12 ES lamps, Electronic Ballast	Electronic	3	34	92
F43ES	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-STD	3	34	130
F43EVS	F48T12/VHO/ES	Fluorescent, (3) 48", VHO ES lamp	Mag-STD	3		333
F43IAL-R	F25T12	Fluorescent, (3) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	60
F43ILL	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	89
F43SILL	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	30	78
F43SILL-R	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	30	70
F43SILL-H	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-3.3)	Electronic	3	30	105
F43SSILL	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	28	72
F43SSILL-R	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	28	66
F43SSILL-H	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-3.3)	Electronic	3	28	98
F43ILL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	90
F43ILL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	93

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F43ILL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	32	78
F43ILL-V	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	3	32	112
F43ILX-H	F32T8	Fluorescent, (3) 48", T-8 lamp, HE Instant/Program Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	90
F43ILX-R	F32T8	Fluorescent, (3) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	3	32	73
F43ILX-R/2	F32T8	Fluorescent, (3) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85), (2) ballast	Electronic	3	32	73
F43LE	F32T8	Fluorescent, (3) 48", T-8 lamp	Mag-ES	3	32	110
F43LL	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	93
F43LL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	92
F43LL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	98
F43LL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	32	76
F43SE	F40T12	Fluorescent, (3) 48", STD lamp	Mag-ES	3	40	136
F43GHL	F48T5/HO	Fluorescent, (3) 48", STD HO T5 lamp	Electronic	3	54	177
F43SHS	F48T12/HO	Fluorescent, (3) 48", STD HO lamp	Mag-STD	3	60	230
F43SIL	F40T12	Fluorescent, (3) 48", STD IS lamp, Electronic ballast	Electronic	3	39	120
F43SIS	F48T12	Fluorescent, (3) 48", STD IS lamp	Mag-STD	3	39	162
F43SS	F40T12	Fluorescent, (3) 48", STD lamp	Mag-STD	3	40	151
F43SVS	F48T12/VHO	Fluorescent, (3) 48", STD VHO lamp	Mag-STD	3	110	377
F44EE	F40T12/ES	Fluorescent, (4) 48", ES lamp	Mag-ES	4	34	144
F44EE/D4	F40T12/ES	Fluorescent, (4) 48", ES lamp, 4 Ballasts (delamped)	Mag-ES	4	34	152
F44EHS	F48T12/HO/ES	Fluorescent, (4) 48", ES HO lamp	Mag-STD	4	55	270
F44EIS	F48T12/ES	Fluorescent, (4) 48" ES Instant Start lamp, Magnetic ballast	Mag-STD	4	30	164
F44EL	F40T12/ES	Fluorescent, (4) 48", T12 ES lamp, Electronic Ballast	Electronic	4	34	120

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F44ES	F40T12/ES	Fluorescent, (4) 48", ES lamp	Mag-STD	4	34	160
F44EVS	F48T12/VHO/ES	Fluorescent, (4) 48", VHO ES lamp	Mag-STD	4		420
F44IAL-R	F25T12	Fluorescent, (4) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	25	80
F44ILL	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	112
F44SILL	F30T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	30	105
F44SILL-R	F30T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	30	91
F44SILL-H	F30T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-4.4)	Electronic	4	30	140
F44SSILL	F28T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	28	96
F44SSILL-R	F28T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	28	86
F44SSILL-H	F28T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-4.4)	Electronic	4	28	131
F44ILL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	118
F44ILL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	32	102
F44ILX-R	F32T8	Fluorescent, (4) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	4	32	96
F44ILX-R/2	F32T8	Fluorescent, (4) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85), (2) ballast	Electronic	4	32	96
F44LE	F32T8	Fluorescent, (4) 48", T-8 lamp	Mag-ES	4	32	142
F44LL	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	118
F44LL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	120
F44LL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	32	105
F44SE	F40T12	Fluorescent, (4) 48", STD lamp	Mag-ES	4	40	172
F44GHL	F48T5/HO	Fluorescent, (4) 48", STD HO T5 lamp	Electronic	4	54	234
F44SHS	F48T12/HO	Fluorescent, (4) 48", STD HO lamp	Mag-STD	4	60	290

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F44SIL	F48T12	Fluorescent, (4) 48", STD IS lamp, Electronic ballast	Electronic	4	39	148
F44SIS	F48T12	Fluorescent, (4) 48", STD IS lamp	Mag-STD	4	39	204
F44SS	F40T12	Fluorescent, (4) 48", STD lamp	Mag-STD	4	40	188
F44SVS	F48T12/VHO	Fluorescent, (4) 48", STD VHO lamp	Mag-STD	4	110	484
F45ILL	F32T8	Fluorescent, (5) 48", T-8 lamp, (1) 3-lamp IS ballast and (1) 2-lamp IS ballast, NLO (BF: .85-.95)	Electronic	5	32	148
F45GHL	F48T5/HO	Fluorescent, (5) 48", STD HO T5 lamp	Electronic	5	54	294
F46EE	F40T12/ES	Fluorescent, (6) 48", ES lamp	Mag-ES	6	34	216
F46EL	F40T12/ES	Fluorescent, (6) 48", ES lamp	Electronic	6	34	186
F46ES	F40T12/ES	Fluorescent, (6) 48", ES lamp	Mag-STD	6	34	236
F46ILL	F32T8	Fluorescent, (6) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	6	32	175
F46ILL-R	F32T8	Fluorescent, (6) 48", T-8 lamp, Instant Start Ballast, RLO (BF< .85)	Electronic	6	32	156
F46ILX-R	F32T8	Fluorescent, (6) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF< .85)	Electronic	6	32	146
F46LL	F32T8	Fluorescent, (6) 48", T-8 lamp, NLO (BF: .85-.95)	Electronic	6	32	182
F46GHL	F48T5/HO	Fluorescent, (6) 48", STD HO T5 lamp	Electronic	6	54	351
F46SE	F40T12	Fluorescent, (6) 48", STD lamp	Mag-ES	6	40	258
F46SS	F40T12	Fluorescent, (6) 48", STD lamp	Mag-STD	6	40	282
F48EE	F40T12/ES	Fluorescent, (8) 48", ES lamp	Mag-ES	8	34	288
F48ILL	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	8	32	224
F48ILL-R	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	8	32	204
F48ILX-R	F32T8	Fluorescent, (8) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	8	32	192
F48GHL	F48T5/HO	Fluorescent, (8) 48", STD HO T5 lamp	Electronic	8	54	468
F51ILHL	F60T12/HO	Fluorescent, (1) 60", T-8 HO lamp, Instant Start Ballast	Electronic	1	55	59
F51ILL	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	40	36

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F51ILL/T2	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	40	36
F51ILL/T3	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	40	35
F51ILL/T4	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	40	34
F51ILL-R	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	40	43
F51SHE	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Mag-ES	1	75	88
F51SHL	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Electronic	1	75	69
F51GHL	F60T5/HO	Fluorescent, (1) 60", STD HO T5 lamp	Electronic	1	80	89
F51SHS	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Mag-STD	1	75	92
F51SL	F60T12	Fluorescent, (1) 60", STD lamp	Electronic	1	50	44
F51GL	F60T5	Fluorescent, (1) 60", STD T5 lamp	Electronic	1	35	39
F51SS	F60T12	Fluorescent, (1) 60", STD lamp	Mag-STD	1	50	63
F51SVS	F60T12/VHO	Fluorescent, (1) 60", VHO ES lamp	Mag-STD	1	135	165
F52ILHL	F60T12/HO	Fluorescent, (2) 60", T-8 HO lamp, Instant Start Ballast	Electronic	2	55	123
F52ILL	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	40	72
F52ILL/T4	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	2	40	67
F52ILL-H	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	40	80
F52ILL-R	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	40	73
F52SHE	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Mag-ES	2	75	176
F52SHL	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Electronic	2	75	138
F52GHL	F60T5/HO	Fluorescent, (2) 60", STD HO T5 lamp	Electronic	2	49	106
F52SHS	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Mag-STD	2	75	168
F52SL	F60T12	Fluorescent, (2) 60", STD lamp	Electronic	2	50	88
F52GL	F60T5	Fluorescent, (2) 60", STD T5 lamp	Electronic	2	35	76
F52SS	F60T12	Fluorescent, (2) 60", STD lamp	Mag-STD	2	50	128

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F52SVS	F60T12/VHO	Fluorescent, (2) 60", VHO ES lamp	Mag-STD	2	135	310
F53ILL	F40T8	Fluorescent, (3) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	40	106
F53ILL-H	F40T8	Fluorescent, (3) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	40	108
F54ILL	F40T8	Fluorescent, (4) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	40	134
F54ILL-H	F40T8	Fluorescent, (4) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	4	40	126
F61ISL	F72T12	Fluorescent, (1) 72", STD lamp, IS electronic ballast	Electronic	1	55	68
F61SE	F72T12	Fluorescent, (1) 72", STD lamp	Mag-ES	1	55	76
F61SHS	F72T12/HO	Fluorescent, (1) 72", STD HO lamp	Mag-STD	1	85	120
F61SS	F72T12	Fluorescent, (1) 72", STD lamp	Mag-STD	1	55	90
F61SVS	F72T12/VHO	Fluorescent, (1) 72", VHO lamp	Mag-STD	1	160	180
F62ILHL	F72T8	Fluorescent, (2) 72", T-8 HO lamp, Instant Start Ballast	Electronic	2	65	147
F62ISL	F72T12	Fluorescent, (2) 72", STD lamp, IS electronic ballast	Electronic	2	55	108
F62SE	F72T12	Fluorescent, (2) 72", STD lamp	Mag-ES	2	55	122
F62SHE	F72T12/HO	Fluorescent, (2) 72", STD HO lamp	Mag-ES	2	85	194
F62SHS	F72T12/HO	Fluorescent, (2) 72", STD HO lamp	Mag-STD	2	85	220
F62SL	F72T12	Fluorescent, (2) 72", STD lamp	Electronic	2	55	108
F62SS	F72T12	Fluorescent, (2) 72", STD lamp	Mag-STD	2	55	145
F62SVS	F72T12/VHO	Fluorescent, (2) 72", VHO lamp	Mag-STD	2	160	330
F63ISL	F72T12	Fluorescent, (3) 72", STD lamp, IS electronic ballast	Electronic	3	55	176
F63SS	F72T12	Fluorescent, (3) 72", STD lamp	Mag-STD	3	55	202
F64ISL	F72T12	Fluorescent, (4) 72", STD lamp, IS electronic ballast	Electronic	4	55	216
F64SE	F72T12	Fluorescent, (4) 72", STD lamp	Mag-ES	4	55	230
F64SHE	F72T12/HO	Fluorescent, (4) 72", STD HO lamp	Mag-ES	4	85	388
F64SS	F72T12	Fluorescent, (4) 72", STD lamp	Mag-STD	4	55	244
F81EE/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, tandem to 2-lamp ballast	Mag-ES	1	60	62
F81EHL	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	Electronic	1	95	80

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F81EHL/T2	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	95	85
F81EHS	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	Mag-STD	1	95	125
F81EL	F96T12/ES	Fluorescent, (1) 96", ES lamp	Electronic	1	60	60
F81EL/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	60	55
F81ES	F96T12/ES	Fluorescent, (1) 96", ES lamp	Mag-STD	1	60	83
F81ES/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, tandem to 2-lamp ballast	Mag-STD	1	60	64
F81EVS	F96T12/VHO/ES	Fluorescent, (1) 96", ES VHO lamp	Mag-STD	1	185	200
F81ILL	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	59	58
F81ILL/T2	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	59	55
F81ILL/T2-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 2 Lamp Ballast	Electronic	1	59	49
F81ILL-H	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	59	68
F81ILL-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	59	57
F81ILL-V	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	1	59	71
F81LHL	F96T8/HO	Fluorescent, (1) 96", T8 HO lamp	Electronic	1	86	85
F81LHL/T2	F96T8/HO	Fluorescent, (1) 96", T8 HO lamp, tandem wired to 2-lamp ballast	Electronic	1	86	80
F81SE	F96T12	Fluorescent, (1) 96", STD lamp	Mag-ES	1	75	91
F81EHS	F96T12/HO	Fluorescent, (1) 96", ES HO lamp	Mag-STD	1	95	125
F81SHE	F96T12/HO	Fluorescent, (1) 96", STD HO lamp	Mag-ES	1	110	132
F81SHL/T2	F96T12/HO	Fluorescent, (1) 96", STD HO lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	110	98
F81SHS	F96T12/HO	Fluorescent, (1) 96", STD HO lamp	Mag-STD	1	110	145

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F81SL	F96T12	Fluorescent, (1) 96", STD lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	75	70
F81SL/T2	F96T12	Fluorescent, (1) 96", STD lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	75	67
F81SS	F96T12	Fluorescent, (1) 96", STD lamp	Mag-STD	1	75	100
F81SVS	F96T12/VHO	Fluorescent, (1) 96", STD VHO lamp	Mag-STD	1	215	230
F82EE	F96T12/ES	Fluorescent, (2) 96", ES lamp	Mag-ES	2	60	123
F82EHE	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Mag-ES	2	95	207
F82EHL	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Electronic	2	95	170
F82EHS	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Mag-STD	2	95	227
F82EL	F96T12/ES	Fluorescent, (2) 96", ES lamp	Electronic	2	60	110
F82ES	F96T12/ES	Fluorescent, (2) 96", ES lamp	Mag-STD	2	60	138
F82EVS	F96T12/VHO/ES	Fluorescent, (2) 96", ES VHO lamp	Mag-STD	2	185	390
F82ILL	F96T8	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	59	109
F82ILL-R	F96T8	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	59	98
F82LHL	F96T8/HO	Fluorescent, (2) 96", T8 HO lamp	Electronic	2	86	160
F82SE	F96T12	Fluorescent, (2) 96", STD lamp	Mag-ES	2	75	158
F82SHE	F96T12/HO	Fluorescent, (2) 96", STD HO lamp	Mag-ES	2	110	237
F82SHL	F96T12/HO	Fluorescent, (2) 96", STD HO lamp	Electronic	2	110	195
F82SHS	F96T12/HO	Fluorescent, (2) 96", STD HO lamp	Mag-STD	2	110	257
F82SL	F96T12	Fluorescent, (2) 96", STD lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	75	134
F82SS	F96T12	Fluorescent, (2) 96", STD lamp	Mag-STD	2	75	173
F82SVS	F96T12/VHO	Fluorescent, (2) 96", STD VHO lamp	Mag-STD	2	215	450
F83EE	F96T12/ES	Fluorescent, (3) 96", ES lamp	Mag-ES	3	60	210
F83EHE	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamp, (1) 2-lamp ES Ballast, (1) 1-lamp STD Ballast	Mag-ES/STD	3	95	319
F83EHS	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamp	Mag-STD	3	95	352
F83EL	F96T12/ES	Fluorescent, (3) 96", ES lamp	Electronic	3	60	179
F83ES	F96T12/ES	Fluorescent, (3) 96", ES lamp	Mag-STD	3	60	221
F83EVS	F96T12/VHO/ES	Fluorescent, (3) 96", ES VHO lamp	Mag-STD	3	185	590
F83ILL	F96T8	Fluorescent, (3) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	59	167
F83SHS	F96T12/HO	Fluorescent, (3) 96", STD HO lamp	Mag-STD	3	110	392

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F83SS	F96T12	Fluorescent, (3) 96", STD lamp	Mag-STD	3	75	273
F83SVS	F96T12/VHO	Fluorescent, (3) 96", STD VHO lamp	Mag-STD	3	215	680
F84EE	F96T12/ES	Fluorescent, (4) 96", ES lamp	Mag-ES	4	60	246
F84EHE	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Mag-ES	4	95	414
F84EHL	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Electronic	4	95	340
F84EHS	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Mag-STD	4	95	454
F84EL	F96T12/ES	Fluorescent, (4) 96", ES lamp	Electronic	4	60	220
F84ES	F96T12/ES	Fluorescent, (4) 96", ES lamp	Mag-STD	4	60	276
F84EVS	F96T12/VHO/ES	Fluorescent, (4) 96", ES VHO lamp	Mag-STD	4	185	780
F84ILL	F96T8	Fluorescent, (4) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	59	219
F84LHL	F96T8/HO	Fluorescent, (4) 96", T8 HO lamp	Electronic	4	86	320
F84SE	F96T12	Fluorescent, (4) 96", STD lamp	Mag-ES	4	75	316
F84SHE	F96T12/HO	Fluorescent, (4) 96", STD HO lamp	Mag-ES	4	110	474
F84SHL	F96T12/HO	Fluorescent, (3) 96", STD HO lamp	Electronic	4	110	390
F84SHS	F96T12/HO	Fluorescent, (4) 96", STD HO lamp	Mag-STD	4	110	514
F84SL	F96T12	Fluorescent, (4) 96", STD lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	75	268
F84SS	F96T12	Fluorescent, (4) 96", STD lamp	Mag-STD	4	75	346
F84SVS	F96T12/VHO	Fluorescent, (4) 96", STD VHO lamp	Mag-STD	4	215	900
F86EHS	F96T12/HO/ES	Fluorescent, (6) 96", ES HO lamp	Mag-STD	6	95	721
F86ILL	F96T8	Fluorescent, (6) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	6	59	328
CIRCLINE FLUORESCENT FIXTURES						
FC12/1	FC12T9	Fluorescent, (1) 12" circular lamp, RS ballast	Mag-STD	1	32	31
FC12/2	FC12T9	Fluorescent, (2) 12" circular lamp, RS ballast	Mag-STD	2	32	62
FC16/1	FC16T9	Fluorescent, (1) 16" circular lamp	Mag-STD	1	40	35
FC20	FC6T9	Fluorescent, Circline, (1) 20W lamp, Preheat ballast	Mag-STD	1	20	20
FC22/1	FC8T9	Fluorescent, Circline, (1) 22W lamp, preheat ballast	Mag-STD	1	22	20
FC22/32/1	FC22/32T9	Fluorescent, Circline, (1) 22W/32W lamp, preheat ballast	Mag-STD	1	22/32	58
FC32/1	FC12T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	Mag-STD	1	32	40

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
FC32/40/1	FC32/40T9	Fluorescent, Circline, (1) 32W/40W lamp, preheat ballast	Mag-STD	1	32/40	80
FC40/1	FC16T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	Mag-STD	1	32	42
FC44/1	FC44T9	Fluorescent, Circline, (1) 44W lamp, preheat ballast	Mag-STD	1	44	46
FC6/1	FC6T9	Fluorescent, (1) 6" circular lamp, RS ballast	Mag-STD	1	20	25
FC8/1	FC8T9	Fluorescent, (1) 8" circular lamp, RS ballast	Mag-STD	1	22	26
FC8/2	FC8T9	Fluorescent, (2) 8" circular lamp, RS ballast	Mag-STD	2	22	52
U-TUBE FLUORESCENT FIXTURES						
FU1EE	FU40T12/ES	Fluorescent, (1) U-Tube, ES lamp	Mag-ES	1	34	43
FU1ILL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, Instant Start ballast	Electronic	1	32	31
FU1LL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp	Electronic	1	32	32
FU1LL-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	1	31	27
FU1ILX-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, HE Instant/Program Start Ballast RLO (BF<0.85)	Electronic	1	31	25
FU2SS	FU40T12	Fluorescent, (2) U-Tube, STD lamp	Mag-STD	2	40	96
FU2SE	FU40T12	Fluorescent, (2) U-Tube, STD lamp	Mag-ES	2	40	85
FU2EE	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamp	Mag-ES	2	34	72
FU2ES	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamp	Mag-STD	2	34	82
FU2ILL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start Ballast	Electronic	2	32	59
FU2ILL/T4	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start Ballast, tandem wired	Electronic	2	32	56
FU2ILL/T4-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start Ballast, RLO, tandem wired	Electronic	2	32	51
FU2ILL-H	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start HLO Ballast	Electronic	2	32	65
FU2ILL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start RLO Ballast	Electronic	2	32	52
FU2ILX-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, HE Instant/Program Start Ballast RLO (BF<0.85)	Electronic	2	31	48
FU2LL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp	Electronic	2	32	60

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
FU2LL/T2	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Tandem 4 lamp ballast	Electronic	2	32	59
FU2LL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	54	31	54
FU3EE	FU40T12/ES	Fluorescent, (3) U-Tube, ES lamp	Mag-ES	3	35	115
FU3ILL	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamp, Instant Start Ballast	Electronic	3	32	89
FU3ILL-R	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamp, Instant Start RLO Ballast	Electronic	3	32	78
STANDARD INCANDESCENT FIXTURES						
I100/1	I100	Incandescent, (1) 100W lamp	N/A	1	100	100
I100/2	I100	Incandescent, (2) 100W lamp	N/A	2	100	200
I100/3	I100	Incandescent, (3) 100W lamp	N/A	3	100	300
I100/4	I100	Incandescent, (4) 100W lamp	N/A	4	100	400
I100/5	I100	Incandescent, (5) 100W lamp	N/A	5	100	500
I1000/1	I1000	Incandescent, (1) 1000W lamp	N/A	1	1000	1000
I100E/1	I100/ES	Incandescent, (1) 100W ES lamp	N/A	1	90	90
I100EL/1	I100/ES/LL	Incandescent, (1) 100W ES/LL lamp	N/A	1	90	90
I120/1	I120	Incandescent, (1) 120W lamp	N/A	1	120	120
I120/2	I120	Incandescent, (2) 120W lamp	N/A	2	120	240
I125/1	I125	Incandescent, (1) 125W lamp	N/A	1	125	125
I135/1	I135	Incandescent, (1) 135W lamp	N/A	1	135	135
I135/2	I135	Incandescent, (2) 135W lamp	N/A	2	135	270
I15/1	I15	Incandescent, (1) 15W lamp	N/A	1	15	15
I15/2	I15	Incandescent, (2) 15W lamp	N/A	2	15	30
I150/1	I150	Incandescent, (1) 150W lamp	N/A	1	150	150
I150/2	I150	Incandescent, (2) 150W lamp	N/A	2	150	300
I1500/1	I1500	Incandescent, (1) 1500W lamp	N/A	1	1500	1500
I150E/1	I150/ES	Incandescent, (1) 150W ES lamp	N/A	1	135	135
I150EL/1	I150/ES/LL	Incandescent, (1) 150W ES/LL lamp	N/A	1	135	135
I170/1	I170	Incandescent, (1) 170W lamp	N/A	1	170	170
I20/1	I20	Incandescent, (1) 20W lamp	N/A	1	20	20
I20/2	I20	Incandescent, (2) 20W lamp	N/A	2	20	40
I200/1	I200	Incandescent, (1) 200W lamp	N/A	1	200	200
I200/2	I200	Incandescent, (2) 200W lamp	N/A	2	200	400
I2000/1	I2000	Incandescent, (1) 2000W lamp	N/A	1	2000	2000

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
I200L/1	I200/LL	Incandescent, (1) 200W LL lamp	N/A	1	200	200
I25/1	I25	Incandescent, (1) 25W lamp	N/A	1	25	25
I25/2	I25	Incandescent, (2) 25W lamp	N/A	2	25	50
I25/4	I25	Incandescent, (4) 25W lamp	N/A	4	25	100
I250/1	I250	Incandescent, (1) 250W lamp	N/A	1	250	250
I300/1	I300	Incandescent, (1) 300W lamp	N/A	1	300	300
I34/1	I34	Incandescent, (1) 34W lamp	N/A	1	34	34
I34/2	I34	Incandescent, (2) 34W lamp	N/A	2	34	68
I36/1	I36	Incandescent, (1) 36W lamp	N/A	1	36	36
I40/1	I40	Incandescent, (1) 40W lamp	N/A	1	40	40
I40/2	I40	Incandescent, (2) 40W lamp	N/A	2	40	80
I400/1	I400	Incandescent, (1) 400W lamp	N/A	1	400	400
I40E/1	I40/ES	Incandescent, (1) 40W ES lamp	N/A	1	34	34
I40EL/1	I40/ES/LL	Incandescent, (1) 40W ES/LL lamp	N/A	1	34	34
I42/1	I42	Incandescent, (1) 42W lamp	N/A	1	42	42
I448/1	I448	Incandescent, (1) 448W lamp	N/A	1	448	448
I45/1	I45	Incandescent, (1) 45W lamp	N/A	1	45	45
I50/1	I50	Incandescent, (1) 50W lamp	N/A	1	50	50
I50/2	I50	Incandescent, (2) 50W lamp	N/A	2	50	100
I500/1	I500	Incandescent, (1) 500W lamp	N/A	1	500	500
I52/1	I52	Incandescent, (1) 52W lamp	N/A	1	52	52
I52/2	I52	Incandescent, (2) 52W lamp	N/A	2	52	104
I54/1	I54	Incandescent, (1) 54W lamp	N/A	1	54	54
I54/2	I54	Incandescent, (2) 54W lamp	N/A	2	54	108
I55/1	I55	Incandescent, (1) 55W lamp	N/A	1	55	55
I55/2	I55	Incandescent, (2) 55W lamp	N/A	2	55	110
I60/1	I60	Incandescent, (1) 60W lamp	N/A	1	60	60
I60/2	I60	Incandescent, (2) 60W lamp	N/A	2	60	120
I60/3	I60	Incandescent, (3) 60W lamp	N/A	3	60	180
I60/4	I60	Incandescent, (4) 60W lamp	N/A	4	60	240
I60/5	I60	Incandescent, (5) 60W lamp	N/A	5	60	300
I60E/1	I60/ES	Incandescent, (1) 60W ES lamp	N/A	1	52	52
I60EL/1	I60/ES/LL	Incandescent, (1) 60W ES/LL lamp	N/A	1	52	52
I65/1	I65	Incandescent, (1) 65W lamp	N/A	1	65	65
I65/2	I65	Incandescent, (2) 65W lamp	N/A	2	65	130
I67/1	I67	Incandescent, (1) 67W lamp	N/A	1	67	67
I67/2	I67	Incandescent, (2) 67W lamp	N/A	2	67	134

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
I67/3	I67	Incandescent, (3) 67W lamp	N/A	3	67	201
I69/1	I69	Incandescent, (1) 69W lamp	N/A	1	69	69
I7.5/1	I7.5	Tungsten exit light, (1) 7.5 W lamp, used in night light application	N/A	1	7.5	8
I7.5/2	I7.5	Tungsten exit light, (2) 7.5 W lamp, used in night light application	N/A	2	7.5	15
I72/1	I72	Incandescent, (1) 72W lamp	N/A	1	72	72
I75/1	I75	Incandescent, (1) 75W lamp	N/A	1	75	75
I75/2	I75	Incandescent, (2) 75W lamp	N/A	2	75	150
I75/3	I75	Incandescent, (3) 75W lamp	N/A	3	75	225
I75/4	I75	Incandescent, (4) 75W lamp	N/A	4	75	300
I750/1	I750	Incandescent, (1) 750W lamp	N/A	1	750	750
I75E/1	I75/ES	Incandescent, (1) 75W ES lamp	N/A	1	67	67
I75EL/1	I75/ES/LL	Incandescent, (1) 75W ES/LL lamp	N/A	1	67	67
I80/1	I80	Incandescent, (1) 80W lamp	N/A	1	80	80
I85/1	I85	Incandescent, (1) 85W lamp	N/A	1	85	85
I90/1	I90	Incandescent, (1) 90W lamp	N/A	1	90	90
I90/2	I90	Incandescent, (2) 90W lamp	N/A	2	90	180
I90/3	I90	Incandescent, (3) 90W lamp	N/A	3	90	270
I93/1	I93	Incandescent, (1) 93W lamp	N/A	1	93	93
I95/1	I95	Incandescent, (1) 95W lamp	N/A	1	95	95
I95/2	I95	Incandescent, (2) 95W lamp	N/A	2	95	190
HALOGEN INCANDESCENT FIXTURES						
H100/1	H100	Halogen Incandescent, (1) 100W lamp	N/A	1	100	100
H1000/1	H1000	Halogen Incandescent, (1) 1000W lamp	N/A	1	1000	1000
H1200/1	H1200	Halogen Incandescent, (1) 1200W lamp	N/A	1	1200	1200
H150/1	H150	Halogen Incandescent, (1) 150W lamp	N/A	1	150	150
H150/2	H150	Halogen Incandescent, (2) 150W lamp	N/A	2	150	300
H1500/1	H1500	Halogen Incandescent, (1) 1500W lamp	N/A	1	1500	1500
H200/1	H200	Halogen Incandescent, (1) 200W lamp	N/A	1	200	200
H250/1	H250	Halogen Incandescent, (1) 250W lamp	N/A	1	250	250
H300/1	H300	Halogen Incandescent, (1) 300W lamp	N/A	1	300	300
H35/1	H35	Halogen Incandescent, (1) 35W lamp	N/A	1	35	35
H350/1	H350	Halogen Incandescent, (1) 350W lamp	N/A	1	350	350
H40/1	H40	Halogen Incandescent, (1) 40W lamp	N/A	1	40	40
H400/1	H400	Halogen Incandescent, (1) 400W lamp	N/A	1	400	400

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
H42/1	H42	Halogen Incandescent, (1) 42W lamp	N/A	1	42	42
H425/1	H425	Halogen Incandescent, (1) 425W lamp	N/A	1	425	425
H45/1	H45	Halogen Incandescent, (1) 45W lamp	N/A	1	45	45
H45/2	H45	Halogen Incandescent, (2) 45W lamp	N/A	2	45	90
H50/1	H50	Halogen Incandescent, (1) 50W lamp	N/A	1	50	50
H50/2	H50	Halogen Incandescent, (2) 50W lamp	N/A	2	50	100
H500/1	H500	Halogen Incandescent, (1) 500W lamp	N/A	1	500	500
H52/1	H52	Halogen Incandescent, (1) 52W lamp	N/A	1	52	52
H55/1	H55	Halogen Incandescent, (1) 55W lamp	N/A	1	55	55
H55/2	H55	Halogen Incandescent, (2) 55W lamp	N/A	2	55	110
H60/1	H60	Halogen Incandescent, (1) 60W lamp	N/A	1	60	60
H72/1	H72	Halogen Incandescent, (1) 72W lamp	N/A	1	72	72
H75/1	H75	Halogen Incandescent, (1) 75W lamp	N/A	1	75	75
H75/2	H75	Halogen Incandescent, (2) 75W lamp	N/A	2	75	150
H750/1	H750	Halogen Incandescent, (1) 750W lamp	N/A	1	750	750
H90/1	H90	Halogen Incandescent, (1) 90W lamp	N/A	1	90	90
H90/2	H90	Halogen Incandescent, (2) 90W lamp	N/A	2	90	180
H900/1	H900	Halogen Incandescent, (1) 900W lamp	N/A	1	900	900
HLV20/1	H20/LV	Halogen Low Voltage Incandescent, (1) 20W lamp	N/A	1	20	30
HLV25/1	H25/LV	Halogen Low Voltage Incandescent, (1) 25W lamp	N/A	1	25	35
HLV35/1	H35/LV	Halogen Low Voltage Incandescent, (1) 35W lamp	N/A	1	35	45
HLV42/1	H42/LV	Halogen Low Voltage Incandescent, (1) 42W lamp	N/A	1	42	52
HLV50/1	H50/LV	Halogen Low Voltage Incandescent, (1) 50W lamp	N/A	1	50	60
HLV65/1	H65/LV	Halogen Low Voltage Incandescent, (1) 65W lamp	N/A	1	65	75
HLV75/1	H75/LV	Halogen Low Voltage Incandescent, (1) 75W lamp	N/A	1	75	85
QL INDUCTION FIXTURES						
QL55/1	QL55	QL Induction, (1) 55W lamp	Generator	1	55	55
QL85/1	QL85	QL Induction, (1) 85W lamp	Generator	1	85	85
QL165/1	QL165	QL Induction, (1) 165W lamp	Generator	1	165	165

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
HIGH PRESSURE SODIUM FIXTURES						
HPS100/1	HPS100	High Pressure Sodium, (1) 100W lamp	CWA	1	100	138
HPS1000/1	HPS1000	High Pressure Sodium, (1) 1000W lamp	CWA	1	1000	1100
HPS150/1	HPS150	High Pressure Sodium, (1) 150W lamp	CWA	1	150	188
HPS200/1	HPS200	High Pressure Sodium, (1) 200W lamp	CWA	1	200	250
HPS225/1	HPS225	High Pressure Sodium, (1) 225W lamp	CWA	1	225	275
HPS250/1	HPS250	High Pressure Sodium, (1) 250W lamp	CWA	1	250	295
HPS310/1	HPS310	High Pressure Sodium, (1) 310W lamp	CWA	1	310	365
HPS35/1	HPS35	High Pressure Sodium, (1) 35W lamp	CWA	1	35	46
HPS360/1	HPS360	High Pressure Sodium, (1) 360W lamp	CWA	1	360	414
HPS400/1	HPS400	High Pressure Sodium, (1) 400W lamp	CWA	1	400	465
HPS50/1	HPS50	High Pressure Sodium, (1) 50W lamp	CWA	1	50	66
HPS600/1	HPS600	High Pressure Sodium, (1) 600W lamp	CWA	1	600	675
HPS70/1	HPS70	High Pressure Sodium, (1) 70W lamp	CWA	1	70	95
HPS750/1	HPS750	High Pressure Sodium, (1) 750W lamp	CWA	1	750	835
METAL HALIDE FIXTURES						
MH100/1	MH100	Metal Halide, (1) 100W lamp	CWA	1	100	128
MH1000/1	MH1000	Metal Halide, (1) 1000W lamp	CWA	1	1000	1080
MH150/1	MH150	Metal Halide, (1) 150W lamp	CWA	1	150	190
MH1500/1	MH1500	Metal Halide, (1) 1500W lamp	CWA	1	1500	1610
MH175/1	MH175	Metal Halide, (1) 175W lamp	CWA	1	175	215
MH1800/1	MH1800	Metal Halide, (1) 1800W lamp	CWA	1	1800	1875
MH200/1	MH200	Metal Halide, (1) 200W lamp	CWA	1	200	232
MH250/1	MH250	Metal Halide, (1) 250W lamp	CWA	1	250	295
MH32/1	MH32	Metal Halide, (1) 32W lamp	CWA	1	32	43
MH300/1	MH300	Metal Halide, (1) 300W lamp	CWA	1	300	342
MH320/1	MH320	Metal Halide, (1) 320W lamp	CWA	1	320	365
MH350/1	MH350	Metal Halide, (1) 350W lamp	CWA	1	350	400
MH360/1	MH360	Metal Halide, (1) 360W lamp	CWA	1	360	430
MH400/1	MH400	Metal Halide, (1) 400W lamp	CWA	1	400	458
MH400/2	MH400	Metal Halide, (2) 400W lamp	CWA	2	400	916
MH450/1	MH450	Metal Halide, (1) 450W lamp	CWA	1	450	508
MH35/1	MH35	Metal Halide, (1) 35W lamp	CWA	1	35	44
MH50/1	MH50	Metal Halide, (1) 50W lamp	CWA	1	50	72
MH70/1	MH70	Metal Halide, (1) 70W lamp	CWA	1	70	95

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
MH750/1	MH750	Metal Halide, (1) 750W lamp	CWA	1	750	850
MHPS/LR/100/1	MHPS100	Metal Halide Pulse Start, (1) 100W lamp w/ Linear Reactor Ballast	LR	1	100	118
MHPS/LR/150/1	MHPS150	Metal Halide Pulse Start, (1) 150W lamp w/ Linear Reactor Ballast	LR	1	150	170
MHPS/LR/175/1	MHPS175	Metal Halide Pulse Start, (1) 175W lamp w/ Linear Reactor Ballast	LR	1	175	194
MHPS/LR/200/1	MHPS200	Metal Halide Pulse Start, (1) 200W lamp w/ Linear Reactor Ballast	LR	1	200	219
MHPS/LR/250/1	MHPS250	Metal Halide Pulse Start, (1) 250W lamp w/ Linear Reactor Ballast	LR	1	250	275
MHPS/LR/300/1	MHPS300	Metal Halide Pulse Start, (1) 300W lamp w/ Linear Reactor Ballast	LR	1	300	324
MHPS/LR/320/1	MHPS320	Metal Halide Pulse Start, (1) 320W lamp w/ Linear Reactor Ballast	LR	1	320	349
MHPS/LR/350/1	MHPS350	Metal Halide Pulse Start, (1) 350W lamp w/ Linear Reactor Ballast	LR	1	350	380
MHPS/LR/400/1	MHPS400	Metal Halide Pulse Start, (1) 400W lamp w/ Linear Reactor Ballast	LR	1	400	435
MHPS/LR/450/1	MHPS450	Metal Halide Pulse Start, (1) 450W lamp w/ Linear Reactor Ballast	LR	1	450	485
MHPS/LR/750/1	MHPS750	Metal Halide Pulse Start, (1) 750W lamp w/ Linear Reactor Ballast	LR	1	750	805
MHPS/SCWA/100/1	MHPS100	Metal Halide Pulse Start, (1) 100W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	100	128
MHPS/SCWA/1000/1	MHPS1000	Metal Halide Pulse Start, (1) 1000W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	1000	1080
MHPS/SCWA/150/1	MHPS150	Metal Halide Pulse Start, (1) 150W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	150	190
MHPS/SCWA/175/1	MHPS175	Metal Halide Pulse Start, (1) 175W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	175	208

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
MHPS/SCWA/200/1	MHPS200	Metal Halide Pulse Start, (1) 200W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	200	232
MHPS/SCWA/250/1	MHPS250	Metal Halide Pulse Start, (1) 250W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	250	288
MHPS/SCWA/300/1	MHPS300	Metal Halide Pulse Start, (1) 300W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	300	342
MHPS/SCWA/320/1	MHPS320	Metal Halide Pulse Start, (1) 320W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	320	368
MHPS/SCWA/350/1	MHPS350	Metal Halide Pulse Start, (1) 350W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	350	400
MHPS/SCWA/400/1	MHPS400	Metal Halide Pulse Start, (1) 400W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	400	450
MHPS/SCWA/450/1	MHPS450	Metal Halide Pulse Start, (1) 450W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	450	506
MHPS/SCWA/750/1	MHPS750	Metal Halide Pulse Start, (1) 750W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	750	815
MERCURY VAPOR FIXTURES						
MV100/1	MV100	Mercury Vapor, (1) 100W lamp	CWA	1	100	125
MV1000/1	MV1000	Mercury Vapor, (1) 1000W lamp	CWA	1	1000	1075
MV175/1	MV175	Mercury Vapor, (1) 175W lamp	CWA	1	175	205
MV250/1	MV250	Mercury Vapor, (1) 250W lamp	CWA	1	250	290
MV40/1	MV40	Mercury Vapor, (1) 40W lamp	CWA	1	40	50
MV400/1	MV400	Mercury Vapor, (1) 400W lamp	CWA	1	400	455
MV400/2	MV400	Mercury Vapor, (2) 400W lamp	CWA	2	400	910
MV50/1	MV50	Mercury Vapor, (1) 50W lamp	CWA	1	50	74
MV700/1	MV700	Mercury Vapor, (1) 700W lamp	CWA	1	700	780
MV75/1	MV75	Mercury Vapor, (1) 75W lamp	CWA	1	75	93

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-23	7/31/2013

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APPENDIX D

HVAC INTERACTIVE EFFECTS MULTIPLIERS

SINGLE-FAMILY RESIDENTIAL

City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.043	0.073	-0.026	-0.214	0.119	0.000	-0.575	0.073	0.000	-0.521	0.000	0.000	0.000	0.000	-0.026
Binghamton	0.034	0.182	-0.014	-0.148	0.169	0.000	-0.603	0.182	0.000	-0.313	0.000	0.000	0.000	0.000	-0.014
Buffalo	0.040	0.171	-0.027	-0.230	0.190	0.000	-0.655	0.171	0.000	-0.551	0.000	0.000	0.000	0.000	-0.027
Massena	0.034	0.112	-0.029	-0.298	0.131	0.000	-0.489	0.112	0.000	-0.607	0.000	0.000	0.000	0.000	-0.029
NYC	0.077	0.085	-0.023	-0.105	0.111	0.000	-0.579	0.085	0.000	-0.403	0.000	0.000	0.000	0.000	-0.023
Poughkeepsie	0.060	0.079	-0.025	-0.160	0.115	0.000	-0.577	0.079	0.000	-0.462	0.000	0.000	0.000	0.000	-0.025
Syracuse	0.045	0.095	-0.019	-0.157	0.119	0.000	-0.615	0.095	0.000	-0.382	0.000	0.000	0.000	0.000	-0.019

MULTI-FAMILY LOW-RISE

City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.020	0.128	-0.017	-0.140	0.150	0.000	-0.329	0.128	0.000	-0.363	0.000	0.000	-0.014	0.000	-0.017
Binghamton	0.003	0.137	-0.018	-0.178	0.151	0.000	-0.384	0.137	0.000	-0.407	0.000	0.000	-0.020	0.000	-0.018
Buffalo	0.014	0.142	-0.017	-0.143	0.157	0.000	-0.332	0.142	0.000	-0.359	0.000	0.000	-0.014	0.000	-0.017
Massena	0.015	0.158	-0.018	-0.161	0.181	0.000	-0.349	0.158	0.000	-0.377	0.000	0.000	-0.013	0.000	-0.018
NYC	0.055	0.136	-0.016	-0.064	0.163	0.000	-0.260	0.136	0.000	-0.320	0.000	0.000	-0.005	0.000	-0.016
Poughkeepsie	0.038	0.132	-0.017	-0.102	0.157	0.000	-0.295	0.132	0.000	-0.342	0.000	0.000	-0.010	0.000	-0.017
Syracuse	0.017	0.140	-0.018	-0.160	0.150	0.000	-0.361	0.140	0.000	-0.391	0.000	0.000	-0.013	0.000	-0.018

MULTI-FAMILY HIGH-RISE

City	Fan coil with chiller and hot water boiler			Steam heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.080	0.113	-0.025	0.000	0.000	-0.028
Binghamton	0.068	0.073	-0.027	0.000	0.000	-0.030
Buffalo	0.072	0.113	-0.026	0.000	0.000	-0.029
Massena	0.073	0.094	-0.026	0.000	0.000	-0.029
NYC	0.101	0.194	-0.021	0.000	0.000	-0.024
Poughkeepsie	0.092	0.168	-0.023	0.000	0.000	-0.026
Syracuse	0.080	0.113	-0.024	0.000	0.000	-0.027

SMALL COMMERCIAL BUILDINGS

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Assembly (Asy)	Albany	0.100	0.200	-0.031	-0.388	0.200	0.000	-0.536	0.200	0.000	-0.644	0.000	0.000	0.000	0.000	-0.032
	Binghamton	0.090	0.200	-0.036	-0.444	0.200	0.000	-0.676	0.200	0.000	-0.778	0.000	0.000	0.000	0.000	-0.036
	Buffalo	0.100	0.200	-0.034	-0.405	0.200	0.000	-0.645	0.200	0.000	-0.757	0.000	0.000	0.000	0.000	-0.036
	Massena	0.090	0.200	-0.041	-0.491	0.200	0.000	-0.653	0.200	0.000	-0.764	0.000	0.000	0.000	0.000	-0.037
	NYC	0.160	0.200	-0.021	-0.052	0.200	0.000	-0.243	0.200	0.000	-0.400	0.000	0.000	0.000	0.000	-0.020
	Poughkeepsie	0.130	0.200	-0.026	-0.361	0.200	0.000	-0.578	0.200	0.000	-0.700	0.000	0.000	0.000	0.000	-0.034
	Syracuse	0.110	0.200	-0.029	-0.364	0.200	0.000	-0.481	0.200	0.000	-0.610	0.000	0.000	0.000	0.000	-0.029
Auto repair (AR)	Albany	0.044	0.200	-0.032	-0.377	0.200	0.000	-0.630	0.200	0.000	-0.699	0.000	0.000	0.000	0.000	-0.032
	Binghamton	0.038	0.200	-0.028	-0.345	0.200	0.000	-0.564	0.200	0.000	-0.614	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.043	0.200	-0.033	-0.316	0.200	0.000	-0.661	0.200	0.000	-0.724	0.000	0.000	0.000	0.000	-0.033
	Massena	0.039	0.200	-0.033	-0.443	0.200	0.000	-0.653	0.200	0.000	-0.715	0.000	0.000	0.000	0.000	-0.033
	NYC	0.076	0.200	-0.041	-0.308	0.200	0.000	-0.795	0.200	0.000	-0.891	0.000	0.000	0.000	0.000	-0.042
	Poughkeepsie	0.057	0.200	-0.037	-0.408	0.200	0.000	-0.726	0.200	0.000	-0.811	0.000	0.000	0.000	0.000	-0.037
	Syracuse	0.046	0.200	-0.036	-0.394	0.200	0.000	-0.727	0.200	0.000	-0.809	0.000	0.000	0.000	0.000	-0.037
Big Box (BB)	Albany	0.120	0.200	-0.023	-0.166	0.200	0.000	-0.330	0.200	0.000	-0.458	0.000	0.000	0.000	0.000	-0.023
	Binghamton	0.110	0.200	-0.023	-0.172	0.200	0.000	-0.330	0.200	0.000	-0.462	0.000	0.000	0.000	0.000	-0.023
	Buffalo	0.110	0.200	-0.023	-0.163	0.200	0.000	-0.299	0.200	0.000	-0.424	0.000	0.000	0.000	0.000	-0.022
	Massena	0.100	0.200	-0.027	-0.298	0.200	0.000	-0.463	0.200	0.000	-0.572	0.000	0.000	0.000	0.000	-0.028
	NYC	0.170	0.200	-0.013	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.145	0.200	-0.018	-0.085	0.200	0.000	-0.200	0.200	0.000	-0.350	0.000	0.000	0.000	0.000	-0.019
	Syracuse	0.120	0.200	-0.022	-0.144	0.200	0.000	-0.301	0.200	0.000	-0.425	0.000	0.000	0.000	0.000	-0.021
Elementary School (Elem)	Albany	0.060	0.200	-0.039	-0.399	0.200	0.000	-0.809	0.200	0.000	-0.916	0.000	0.000	0.000	0.000	-0.040
	Binghamton	0.040	0.200	-0.041	-0.406	0.200	0.000	-0.818	0.200	0.000	-0.950	0.000	0.000	0.000	0.000	-0.042
	Buffalo	0.040	0.200	-0.041	-0.382	0.200	0.000	-0.773	0.200	0.000	-0.908	0.000	0.000	0.000	0.000	-0.040
	Massena	0.040	0.200	-0.044	-0.509	0.200	0.000	-0.850	0.200	0.000	-0.963	0.000	0.000	0.000	0.000	-0.042
	NYC	0.110	0.200	-0.029	-0.150	0.200	0.000	-0.481	0.200	0.000	-0.646	0.000	0.000	0.000	0.000	-0.029
	Poughkeepsie	0.085	0.200	-0.034	-0.327	0.200	0.000	-0.743	0.200	0.000	-0.907	0.000	0.000	0.000	0.000	-0.040
	Syracuse	0.060	0.200	-0.039	-0.385	0.200	0.000	-0.778	0.200	0.000	-0.902	0.000	0.000	0.000	0.000	-0.040
Fast Food (FF)	Albany	0.070	0.200	-0.037	-0.702	0.200	0.000	-0.702	0.200	0.000	-0.818	0.000	0.000	0.000	0.000	-0.039
	Binghamton	0.060	0.200	-0.035	-0.732	0.200	0.000	-0.732	0.200	0.000	-0.808	0.000	0.000	0.000	0.000	-0.038
	Buffalo	0.070	0.200	-0.036	-0.677	0.200	0.000	-0.677	0.200	0.000	-0.815	0.000	0.000	0.000	0.000	-0.038
	Massena	0.070	0.200	-0.036	-0.717	0.200	0.000	-0.717	0.200	0.000	-0.814	0.000	0.000	0.000	0.000	-0.039
	NYC	0.110	0.200	-0.028	-0.471	0.200	0.000	-0.471	0.200	0.000	-0.827	0.000	0.000	0.000	0.000	-0.040
	Poughkeepsie	0.090	0.200	-0.033	-0.660	0.200	0.000	-0.660	0.200	0.000	-0.816	0.000	0.000	0.000	0.000	-0.039
	Syracuse	0.070	0.200	-0.035	-0.682	0.200	0.000	-0.682	0.200	0.000	-0.817	0.000	0.000	0.000	0.000	-0.039
Full Service Restaurant (FS)	Albany	0.070	0.200	-0.039	-0.656	0.200	0.000	-0.656	0.200	0.000	-0.792	0.000	0.000	0.000	0.000	-0.037
	Binghamton	0.060	0.200	-0.038	-0.738	0.200	0.000	-0.738	0.200	0.000	-0.856	0.000	0.000	0.000	0.000	-0.041
	Buffalo	0.070	0.200	-0.037	-0.645	0.200	0.000	-0.645	0.200	0.000	-0.777	0.000	0.000	0.000	0.000	-0.037
	Massena	0.060	0.200	-0.038	-0.720	0.200	0.000	-0.720	0.200	0.000	-0.821	0.000	0.000	0.000	0.000	-0.039
	NYC	0.110	0.200	-0.030	-0.486	0.200	0.000	-0.486	0.200	0.000	-0.637	0.000	0.000	0.000	0.000	-0.032
	Poughkeepsie	0.090	0.200	-0.035	-0.573	0.200	0.000	-0.573	0.200	0.000	-0.756	0.000	0.000	0.000	0.000	-0.037
	Syracuse	0.080	0.200	-0.037	-0.631	0.200	0.000	-0.631	0.200	0.000	-0.762	0.000	0.000	0.000	0.000	-0.036

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Grocery	Albany	0.120	0.200	-0.023	-0.166	0.200	0.000	-0.330	0.200	0.000	-0.458	0.000	0.000	0.000	0.000	-0.023
	Binghamton	0.110	0.200	-0.023	-0.172	0.200	0.000	-0.330	0.200	0.000	-0.462	0.000	0.000	0.000	0.000	-0.023
	Buffalo	0.110	0.200	-0.023	-0.163	0.200	0.000	-0.299	0.200	0.000	-0.424	0.000	0.000	0.000	0.000	-0.022
	Massena	0.100	0.200	-0.027	-0.298	0.200	0.000	-0.463	0.200	0.000	-0.572	0.000	0.000	0.000	0.000	-0.028
	NYC	0.170	0.200	-0.013	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.145	0.200	-0.018	-0.085	0.200	0.000	-0.200	0.200	0.000	-0.350	0.000	0.000	0.000	0.000	-0.019
	Syracuse	0.120	0.200	-0.022	-0.144	0.200	0.000	-0.301	0.200	0.000	-0.425	0.000	0.000	0.000	0.000	-0.021
Light Industrial (Ind)	Albany	0.070	0.200	-0.026	-0.213	0.200	0.000	-0.456	0.200	0.000	-0.539	0.000	0.000	0.000	0.000	-0.026
	Binghamton	0.060	0.200	-0.028	-0.277	0.200	0.000	-0.507	0.200	0.000	-0.582	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.060	0.200	-0.028	-0.236	0.200	0.000	-0.474	0.200	0.000	-0.550	0.000	0.000	0.000	0.000	-0.027
	Massena	0.060	0.200	-0.028	-0.286	0.200	0.000	-0.490	0.200	0.000	-0.568	0.000	0.000	0.000	0.000	-0.027
	NYC	0.100	0.200	-0.021	-0.083	0.200	0.000	-0.313	0.200	0.000	-0.415	0.000	0.000	0.000	0.000	-0.020
	Poughkeepsie	0.085	0.200	-0.024	-0.165	0.200	0.000	-0.399	0.200	0.000	-0.491	0.000	0.000	0.000	0.000	-0.024
	Syracuse	0.070	0.200	-0.026	-0.218	0.200	0.000	-0.459	0.200	0.000	-0.542	0.000	0.000	0.000	0.000	-0.026
Motel (Motel)	Albany	0.080	0.200	-0.027	-0.318	0.200	0.000	-0.485	0.200	0.000	-0.586	0.000	0.000	0.000	0.000	-0.028
	Binghamton	0.069	0.200	-0.028	-0.342	0.200	0.000	-0.519	0.200	0.000	-0.613	0.000	0.000	0.000	0.000	-0.029
	Buffalo	0.073	0.200	-0.028	-0.314	0.200	0.000	-0.495	0.200	0.000	-0.597	0.000	0.000	0.000	0.000	-0.028
	Massena	0.068	0.200	-0.030	-0.383	0.200	0.000	-0.537	0.200	0.000	-0.627	0.000	0.000	0.000	0.000	-0.029
	NYC	0.114	0.200	-0.023	-0.155	0.200	0.000	-0.340	0.200	0.000	-0.482	0.000	0.000	0.000	0.000	-0.023
	Poughkeepsie	0.097	0.200	-0.025	-0.271	0.200	0.000	-0.453	0.200	0.000	-0.577	0.000	0.000	0.000	0.000	-0.027
	Syracuse	0.081	0.200	-0.027	-0.313	0.200	0.000	-0.485	0.200	0.000	-0.591	0.000	0.000	0.000	0.000	-0.028
Religious (Rel)	Albany	0.078	0.200	-0.012	-0.119	0.200	0.000	-0.193	0.200	0.000	-0.274	0.000	0.000	0.000	0.000	-0.012
	Binghamton	0.071	0.200	-0.013	-0.122	0.200	0.000	-0.229	0.200	0.000	-0.309	0.000	0.000	0.000	0.000	-0.013
	Buffalo	0.075	0.200	-0.011	-0.117	0.200	0.000	-0.194	0.200	0.000	-0.272	0.000	0.000	0.000	0.000	-0.012
	Massena	0.069	0.200	-0.013	-0.151	0.200	0.000	-0.219	0.200	0.000	-0.289	0.000	0.000	0.000	0.000	-0.013
	NYC	0.092	0.200	-0.013	-0.060	0.200	0.000	-0.199	0.200	0.000	-0.291	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.089	0.200	-0.013	-0.078	0.200	0.000	-0.220	0.200	0.000	-0.310	0.000	0.000	0.000	0.000	-0.013
	Syracuse	0.081	0.200	-0.012	-0.118	0.200	0.000	-0.204	0.200	0.000	-0.285	0.000	0.000	0.000	0.000	-0.012
Small Office (SOfc)	Albany	0.100	0.200	-0.019	-0.112	0.200	0.000	-0.283	0.200	0.000	-0.376	0.000	0.000	0.000	0.000	-0.019
	Binghamton	0.090	0.200	-0.021	-0.145	0.200	0.000	-0.321	0.200	0.000	-0.413	0.000	0.000	0.000	0.000	-0.021
	Buffalo	0.090	0.200	-0.020	-0.129	0.200	0.000	-0.307	0.200	0.000	-0.405	0.000	0.000	0.000	0.000	-0.020
	Massena	0.090	0.200	-0.021	-0.177	0.200	0.000	-0.333	0.200	0.000	-0.426	0.000	0.000	0.000	0.000	-0.021
	NYC	0.120	0.200	-0.015	-0.003	0.200	0.000	-0.157	0.200	0.000	-0.239	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.110	0.200	-0.017	-0.061	0.200	0.000	-0.219	0.200	0.000	-0.335	0.000	0.000	0.000	0.000	-0.017
	Syracuse	0.100	0.200	-0.020	-0.119	0.200	0.000	-0.286	0.200	0.000	-0.383	0.000	0.000	0.000	0.000	-0.019
Small Retail (SRet)	Albany	0.100	0.200	-0.027	-0.191	0.200	0.000	-0.428	0.200	0.000	-0.555	0.000	0.000	0.000	0.000	-0.027
	Binghamton	0.090	0.200	-0.029	-0.190	0.200	0.000	-0.448	0.200	0.000	-0.568	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.090	0.200	-0.028	-0.205	0.200	0.000	-0.447	0.200	0.000	-0.555	0.000	0.000	0.000	0.000	-0.027
	Massena	0.080	0.200	-0.031	-0.264	0.200	0.000	-0.535	0.200	0.000	-0.632	0.000	0.000	0.000	0.000	-0.031
	NYC	0.130	0.200	-0.022	-0.044	0.200	0.000	-0.258	0.200	0.000	-0.375	0.000	0.000	0.000	0.000	-0.019
	Poughkeepsie	0.115	0.200	-0.025	-0.137	0.200	0.000	-0.350	0.200	0.000	-0.481	0.000	0.000	0.000	0.000	-0.024
	Syracuse	0.090	0.200	-0.028	-0.180	0.200	0.000	-0.451	0.200	0.000	-0.563	0.000	0.000	0.000	0.000	-0.028

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Warehouse (WH)	Albany	0.063	0.200	-0.016	-0.170	0.200	0.000	-0.311	0.200	0.000	-0.373	0.000	0.000	0.000	0.000	-0.016
	Binghamton	0.054	0.200	-0.017	-0.187	0.200	0.000	-0.341	0.200	0.000	-0.397	0.000	0.000	0.000	0.000	-0.017
	Buffalo	0.054	0.200	-0.016	-0.178	0.200	0.000	-0.325	0.200	0.000	-0.380	0.000	0.000	0.000	0.000	-0.016
	Massena	0.055	0.200	-0.014	-0.156	0.200	0.000	-0.280	0.200	0.000	-0.335	0.000	0.000	0.000	0.000	-0.014
	NYC	0.078	0.200	-0.015	-0.109	0.200	0.000	-0.273	0.200	0.000	-0.352	0.000	0.000	0.000	0.000	-0.015
	Poughkeepsie	0.073	0.200	-0.017	-0.127	0.200	0.000	-0.312	0.200	0.000	-0.388	0.000	0.000	0.000	0.000	-0.017
	Syracuse	0.066	0.200	-0.017	-0.205	0.200	0.000	-0.334	0.200	0.000	-0.401	0.000	0.000	0.000	0.000	-0.017
Other	Albany	0.080	0.200	-0.027	-0.318	0.200	0.000	-0.485	0.200	0.000	-0.586	0.000	0.000	0.000	0.000	-0.028
	Binghamton	0.069	0.200	-0.028	-0.342	0.200	0.000	-0.519	0.200	0.000	-0.613	0.000	0.000	0.000	0.000	-0.029
	Buffalo	0.073	0.200	-0.028	-0.314	0.200	0.000	-0.495	0.200	0.000	-0.597	0.000	0.000	0.000	0.000	-0.028
	Massena	0.068	0.200	-0.030	-0.383	0.200	0.000	-0.537	0.200	0.000	-0.627	0.000	0.000	0.000	0.000	-0.029
	NYC	0.114	0.200	-0.023	-0.155	0.200	0.000	-0.340	0.200	0.000	-0.482	0.000	0.000	0.000	0.000	-0.023
	Poughkeepsie	0.097	0.200	-0.025	-0.271	0.200	0.000	-0.453	0.200	0.000	-0.577	0.000	0.000	0.000	0.000	-0.027
	Syracuse	0.081	0.200	-0.027	-0.313	0.200	0.000	-0.485	0.200	0.000	-0.591	0.000	0.000	0.000	0.000	-0.028

Large Commercial Buildings

Building	City	CV Noecon			CV Econ			VAV Econ		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Community College (CC)	Albany	0.045	0.200	-0.014	0.016	0.200	-0.015	0.080	0.200	-0.007
	Binghamton	0.042	0.200	-0.009	0.014	0.200	-0.010	0.064	0.200	-0.005
	Buffalo	0.042	0.200	-0.011	0.014	0.200	-0.012	0.065	0.200	-0.005
	Massena	0.040	0.200	-0.015	0.013	0.200	-0.015	0.043	0.200	-0.008
	NYC	0.044	0.200	-0.025	0.019	0.200	-0.024	0.124	0.200	-0.003
	Poughkeepsie	0.040	0.200	-0.022	0.014	0.200	-0.021	0.083	0.200	-0.009
	Syracuse	0.045	0.200	-0.017	0.016	0.200	-0.017	0.087	0.200	-0.005
High School (HS)	Albany	0.033	0.200	-0.027	0.014	0.200	-0.027	0.037	0.200	-0.021
	Binghamton	0.028	0.200	-0.028	0.009	0.200	-0.028	0.030	0.200	-0.022
	Buffalo	0.031	0.200	-0.027	0.010	0.200	-0.027	0.035	0.200	-0.021
	Massena	0.030	0.200	-0.028	0.012	0.200	-0.027	0.026	0.200	-0.023
	NYC	0.042	0.200	-0.026	0.022	0.200	-0.025	0.049	0.200	-0.020
	Poughkeepsie	0.037	0.200	-0.028	0.016	0.200	-0.027	0.034	0.200	-0.023
	Syracuse	0.033	0.200	-0.028	0.015	0.200	-0.027	0.037	0.200	-0.022
Hospital (Hosp)	Albany	0.029	0.200	-0.021	0.014	0.200	-0.021	0.045	0.200	-0.016
	Binghamton	0.027	0.200	-0.021	0.011	0.200	-0.021	0.039	0.200	-0.015
	Buffalo	0.027	0.200	-0.021	0.012	0.200	-0.021	0.044	0.200	-0.015
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015

Building	City	CV Noecon			CV Econ			VAV Econ		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Hotel (Hotel)	Albany	0.029	0.200	-0.021	0.014	0.200	-0.021	0.045	0.200	-0.016
	Binghamton	0.027	0.200	-0.021	0.011	0.200	-0.021	0.039	0.200	-0.015
	Buffalo	0.027	0.200	-0.021	0.012	0.200	-0.021	0.044	0.200	-0.015
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015
Large Office (LOfc)	Albany	0.029	0.200	-0.021	0.014	0.200	-0.021	0.045	0.200	-0.016
	Binghamton	0.027	0.200	-0.021	0.011	0.200	-0.021	0.039	0.200	-0.015
	Buffalo	0.027	0.200	-0.021	0.012	0.200	-0.021	0.044	0.200	-0.015
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015
Large Retail (LRet)	Albany	0.031	0.200	-0.027	0.018	0.200	-0.027	0.043	0.200	-0.024
	Binghamton	0.032	0.200	-0.027	0.015	0.200	-0.028	0.044	0.200	-0.023
	Buffalo	0.030	0.200	-0.026	0.017	0.200	-0.028	0.045	0.200	-0.022
	Massena	0.029	0.200	-0.028	0.016	0.200	-0.029	0.036	0.200	-0.026
	NYC	0.037	0.200	-0.023	0.023	0.200	-0.024	0.057	0.200	-0.017
	Poughkeepsie	0.033	0.200	-0.025	0.018	0.200	-0.025	0.056	0.200	-0.019
	Syracuse	0.032	0.200	-0.027	0.017	0.200	-0.029	0.044	0.200	-0.024
University (Univ)	Albany	0.051	0.200	-0.023	0.018	0.200	-0.025	0.111	0.200	-0.012
	Binghamton	0.049	0.200	-0.019	0.014	0.200	-0.020	0.098	0.200	-0.012
	Buffalo	0.052	0.200	-0.020	0.018	0.200	-0.022	0.104	0.200	-0.012
	Massena	0.042	0.200	-0.025	0.012	0.200	-0.027	0.086	0.200	-0.014
	NYC	0.048	0.200	-0.027	0.020	0.200	-0.028	0.142	0.200	-0.010
	Poughkeepsie	0.044	0.200	-0.027	0.014	0.200	-0.028	0.120	0.200	-0.009
	Syracuse	0.047	0.200	-0.024	0.016	0.200	-0.026	0.110	0.200	-0.012

College Dormitory

City	Fan coil with chiller and hot water boiler			Steam heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.029	.200	-0.014	0.000	0.000	-0.015
Binghamton	0.029	.200	-0.014	0.000	0.000	-0.016
Buffalo	0.027	.200	-0.014	0.000	0.000	-0.016
Massena	0.025	.200	-0.015	0.000	0.000	-0.016
NYC	0.025	.200	-0.012	0.000	0.000	-0.013
Poughkeepsie	0.035	.200	-0.014	0.000	0.000	-0.015
Syracuse	0.028	.200	-0.014	0.000	0.000	-0.016

REFRIGERATED WAREHOUSE

City	Water Cooled Ammonia Screw Compressors	
	HVACc	HVACd
Albany	0.370	.200
Binghamton	0.400	.200
Buffalo	0.400	.200
Massena	0.390	.200
NYC	0.390	.200
Poughkeepsie	0.410	.200
Syracuse	0.390	.200

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010

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APPENDIX E

OPAQUE SHELL MEASURE SAVINGS

SINGLE-FAMILY RESIDENTIAL INSULATION UPGRADES

Building: Single-Family Low-rise City: Albany HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	51.2	0.065	51.9												
13	58.7	0.076	60.3	7.6	0.011	8.3									
17	70.2	0.098	72.1	19.1	0.033	20.2	11.5	0.022	11.8						
19	74.1	0.098	76.4	23.0	0.033	24.5	15.4	0.022	16.2	3.9	0.000	4.3			
21	77.9	0.108	80.0	26.8	0.043	28.1	19.2	0.033	19.7	7.7	0.011	7.9	3.8	0.011	3.6
25	83.0	0.108	85.6	31.9	0.043	33.7	24.3	0.033	25.4	12.8	0.011	13.5	8.9	0.011	9.2
27	85.3	0.119	87.9	34.1	0.054	36.0	26.6	0.043	15.8	15.1	0.022	15.8	11.2	0.022	11.5

Building: Single-Family City: Albany HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	772.8	0.043								
13	896.3	0.054	123.5	0.011						
17	1,065.6	0.065	292.8	0.022	169.3	0.011				
19	1,126.6	0.076	353.8	0.033	230.3	0.022	61.0	0.011		
21	1,178.0	0.076	405.2	0.033	281.7	0.022	112.4	0.011	51.4	0.000
25	1,257.9	0.076	485.0	0.033	361.6	0.022	192.3	0.011	131.3	0.000
27	1,290.5	0.087	517.7	0.043	224.9	0.033	224.9	0.022	163.9	0.011

Building: Single-Family City: Albany HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,192.1	0.065								
13	1,382.2	0.076	190.1	0.011						
17	1,650.6	0.098	458.5	0.033	268.4	0.022				
19	1,748.1	0.098	556.0	0.033	365.9	0.022	97.6	0.000		
21	1,830.2	0.108	638.1	0.043	448.0	0.033	179.6	0.011	82.1	0.011
25	1,958.5	0.108	766.4	0.043	576.3	0.033	307.9	0.011	210.4	0.011
27	2,010.2	0.119	818.1	0.054	628.0	0.043	359.6	0.022	262.1	0.022

Building: Single-Family **City: Albany** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,166.2	00.0								
13	1,352.7	00.0	186.5	00.0						
17	1,615.2	00.0	449.1	00.0	262.5	00.0				
19	1,710.9	00.0	544.8	00.0	358.2	00.0	95.7	00.0		
21	1,790.9	00.0	624.8	00.0	438.2	00.0	175.7	00.0	80.0	00.0
25	1,916.9	00.0	750.7	00.0	564.2	00.0	301.6	00.0	205.9	00.0
27	1,967.4	00.0	801.2	00.0	614.7	00.0	352.2	00.0	256.4	00.0

Building: Single-Family **City: Albany** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	25.1	00.0	51.9												
13	29.2	00.0	60.3	4.0	00.0	8.3									
17	34.9	00.0	72.1	9.8	00.0	20.2	5.7	00.0	11.8						
19	37.0	00.0	76.4	11.8	00.0	24.5	7.8	00.0	16.2	2.1	00.0	4.3			
21	38.7	00.0	80.0	13.5	00.0	28.1	9.5	00.0	19.7	3.8	00.0	7.9	1.7	00.0	3.6
25	41.4	00.0	85.6	16.3	00.0	33.7	12.2	00.0	25.4	6.5	00.0	13.5	4.4	00.0	9.2
27	42.5	00.0	87.9	17.3	00.0	36.0	13.3	00.0	27.6	7.6	00.0	15.8	5.5	00.0	11.5

Building: Single-Family **City: Albany** **HVAC: AC with Gas Heat** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	336.9	0.119	322.4												
19	380.5	0.188	362.3	43.7	0.068	39.9									
30	403.4	0.222	385.8	66.6	0.102	63.5	22.9	0.034	23.5						
38	414.8	0.239	395.1	78.0	0.119	72.7	34.3	0.051	32.8	11.4	0.017	9.2			
49	421.2	0.239	403.1	84.3	0.119	80.7	40.6	0.051	40.8	17.7	0.017	17.2	6.3	0.000	8.0
60	425.4	0.256	408.4	88.6	0.137	86.0	44.9	0.068	46.1	22.0	0.034	22.5	10.6	0.017	13.3

Building: Single-Family City: Albany HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,582.8	0.188								
19	6,213.0	0.239	630.2	0.051						
30	6,570.8	0.273	988.1	0.085	357.8	0.034				
38	6,710.4	0.273	1,127.6	0.085	497.4	0.034	139.6	0.000		
49	6,828.0	0.290	1,245.2	0.102	615.0	0.051	257.2	0.017	117.6	0.017
60	6,904.8	0.290	1,322.0	0.102	691.8	0.051	334.0	0.017	194.4	0.017

Building: Single-Family City: Albany HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,631.9	0.119								
19	8,563.5	0.188	931.6	0.068						
30	9,106.8	0.222	1,474.9	0.102	543.3	0.034				
38	9,320.3	0.239	1,688.4	0.119	756.8	0.051	213.5	0.017		
49	9,502.6	0.239	1,870.6	0.119	939.1	0.051	395.7	0.017	182.3	0.000
60	9,621.8	0.256	1,989.9	0.137	1,058.4	0.068	515.0	0.034	301.5	0.017

Building: Single-Family City: Albany HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,449.5	00.0								
19	8,356.1	00.0	906.7	00.0						
30	8,887.5	00.0	1,438.1	00.0	531.4	00.0				
38	9,093.9	00.0	1,644.4	00.0	737.7	00.0	206.3	00.0		
49	9,273.5	00.0	1,824.1	00.0	917.4	00.0	386.0	00.0	179.7	00.0
60	9,391.0	00.0	1,941.5	00.0	1,034.8	00.0	503.4	00.0	297.1	00.0

Building: Single-Family City: Albany HVAC: Gas Heat No AC Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm / kSF	kWh / kSF	kW/ kSF	therm / kSF	kWh / kSF	kW/ kSF	therm / kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh / kSF	kW/ kSF	therm / kSF
11	154.6	00.0	322.5												
19	173.4	00.0	362.5	18.8	00.0	39.9									
30	184.3	00.0	386.0	29.7	00.0	63.5	10.9	00.0	23.5						
38	188.6	00.0	395.2	34.0	00.0	72.7	15.2	00.0	32.8	4.3	00.0	9.2			
49	192.3	00.0	403.2	37.7	00.0	80.7	18.9	00.0	40.8	8.0	00.0	17.2	3.8	00.0	8.0
60	194.7	00.0	408.5	40.1	00.0	86.0	21.3	00.0	46.1	10.4	00.0	22.5	6.1	00.0	13.3

Building: Single-Family City: Buffalo HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	46.4	0.043	54.2												
13	53.7	0.043	62.8	7.3	0.000	8.6									
17	64.9	0.054	74.9	18.5	0.011	20.7	11.3	0.011	12.1						
19	68.6	0.054	79.3	22.2	0.011	25.1	15.0	0.011	16.6	3.7	0.000	4.4			
21	71.3	0.054	83.0	24.9	0.011	28.8	17.7	0.011	20.3	6.4	0.000	8.1	2.7	0.000	3.7
25	76.0	0.054	88.9	29.6	0.011	34.7	22.3	0.011	26.1	11.1	0.000	14.0	7.4	0.000	9.5
27	77.0	0.065	91.2	30.6	0.022	37.0	23.3	0.022	16.3	12.0	0.011	16.3	8.3	0.011	11.8

Building: Single-Family City: Buffalo HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	841.3	0.043								
13	972.3	0.043	130.9	0.000						
17	1,154.8	0.054	313.5	0.011	182.5	0.011				
19	1,221.2	0.054	379.9	0.011	249.0	0.011	66.4	0.000		
21	1,275.0	0.054	433.7	0.011	302.7	0.011	120.2	0.000	53.8	0.000
25	1,360.1	0.065	518.8	0.022	387.8	0.022	205.3	0.011	138.8	0.011
27	1,394.0	0.065	552.7	0.022	239.2	0.022	239.2	0.011	172.8	0.011

Building: Single-Family City: Buffalo HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,246.8	0.043								
13	1,444.4	0.043	197.6	0.000						
17	1,722.6	0.054	475.8	0.011	278.2	0.011				
19	1,823.7	0.054	576.8	0.011	379.3	0.011	101.0	0.000		
21	1,907.4	0.054	660.6	0.011	463.0	0.011	184.8	0.000	83.8	0.000
25	2,039.8	0.054	793.0	0.011	595.4	0.011	317.1	0.000	216.1	0.000
27	2,091.9	0.065	845.1	0.022	647.5	0.022	369.3	0.011	268.3	0.011

Building: Single-Family City: Buffalo HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,227.4	00.0								
13	1,422.0	00.0	194.6	00.0						
17	1,694.9	00.0	467.5	00.0	272.9	00.0				
19	1,794.4	00.0	567.0	00.0	372.4	00.0	99.5	00.0		
21	1,877.4	00.0	650.0	00.0	455.5	00.0	182.5	00.0	83.0	00.0
25	2,007.9	00.0	780.5	00.0	586.0	00.0	313.0	00.0	213.5	00.0
27	2,060.2	00.0	832.8	00.0	638.2	00.0	365.3	00.0	265.8	00.0

Building: Single-Family City: Buffalo HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	26.9	00.0	54.2												
13	31.2	00.0	62.8	4.3	00.0	8.6									
17	37.2	00.0	74.9	10.3	00.0	20.7	6.0	00.0	12.1						
19	39.3	00.0	79.3	12.5	00.0	25.1	8.1	00.0	16.6	2.2	00.0	4.4			
21	41.2	00.0	83.0	14.3	00.0	28.8	10.0	00.0	20.3	4.0	00.0	8.1	1.8	00.0	3.7
25	44.0	00.0	88.9	17.1	00.0	34.7	12.8	00.0	26.1	6.8	00.0	14.0	4.7	00.0	9.5
27	45.2	00.0	91.3	18.3	00.0	37.1	14.0	00.0	28.5	8.0	00.0	16.4	5.9	00.0	11.9

Building: Single-Family City: Buffalo HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	292.5	0.256	320.6												
19	327.0	0.290	360.6	34.5	0.034	39.9									
30	350.3	0.307	384.0	57.8	0.051	63.3	23.4	0.017	23.4						
38	357.0	0.324	393.2	64.5	0.068	72.5	30.0	0.034	32.6	6.7	0.017	9.2			
49	366.7	0.324	401.2	74.2	0.068	80.5	39.8	0.034	40.6	16.4	0.017	17.2	9.7	0.000	8.0
60	370.5	0.324	406.5	78.0	0.068	85.8	43.5	0.034	45.9	20.1	0.017	22.5	13.5	0.000	13.3

Building: Single-Family City: Buffalo HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,565.7	0.239								
19	6,216.2	0.273	650.5	0.034						
30	6,586.5	0.307	1,020.8	0.068	370.3	0.034				
38	6,729.7	0.307	1,164.0	0.068	513.5	0.034	143.2	0.000		
49	6,857.7	0.307	1,292.0	0.068	641.5	0.034	271.2	0.000	128.0	0.000
60	6,938.4	0.307	1,372.7	0.068	722.2	0.034	351.9	0.000	208.7	0.000

Building: Single-Family City: Buffalo HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,602.2	0.256								
19	8,528.5	0.290	926.3	0.034						
30	9,073.4	0.307	1,471.2	0.051	544.9	0.017				
38	9,284.0	0.324	1,681.7	0.068	755.5	0.034	210.6	0.017		
49	9,472.2	0.324	1,870.0	0.068	943.7	0.034	398.8	0.017	188.2	0.000
60	9,592.3	0.324	1,990.1	0.068	1,063.8	0.034	518.9	0.017	308.4	0.000

Building: Single-Family City: Buffalo HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,464.7	00.0								
19	8,375.4	00.0	910.8	00.0						
30	8,907.8	00.0	1,443.2	00.0	532.4	00.0				
38	9,116.2	00.0	1,651.5	00.0	740.8	00.0	208.4	00.0		
49	9,298.5	00.0	1,833.8	00.0	923.0	00.0	390.6	00.0	182.3	00.0
60	9,417.2	00.0	1,952.6	00.0	1,041.8	00.0	509.4	00.0	301.0	00.0

Building: Single-Family City: Buffalo HVAC: Gas Heat No AC Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm / kSF	kWh / kSF	kW/ kSF	therm / kSF	kWh / kSF	kW/ kSF	therm / kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh / kSF	kW/ kSF	therm / kSF
11	154.9	00.0	320.6												
19	173.9	00.0	360.6	18.9	00.0	39.9									
30	184.8	00.0	384.0	29.9	00.0	63.3	10.9	00.0	23.4						
38	189.2	00.0	393.2	34.3	00.0	72.5	15.4	00.0	32.6	4.4	00.0	9.2			
49	193.0	00.0	401.2	38.1	00.0	80.5	19.1	00.0	40.6	8.2	00.0	17.2	3.8	00.0	8.0
60	195.4	00.0	406.5	40.4	00.0	85.8	21.5	00.0	45.9	10.6	00.0	22.5	6.1	00.0	13.3

Building: Single-family **City: Massena** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	53.2	0.065	61.7												
13	61.1	0.076	71.5	7.9	0.011	9.9									
17	72.9	0.087	85.5	19.7	0.022	23.8	11.8	0.011	14.0						
19	77.5	0.098	90.7	24.3	0.033	29.0	16.4	0.022	19.2	4.6	0.011	5.2			
21	80.2	0.098	94.9	27.0	0.033	33.3	19.1	0.022	23.4	7.3	0.011	9.4	2.7	0.000	4.2
25	87.4	0.108	101.7	34.1	0.043	40.0	26.2	0.033	30.1	14.4	0.022	16.2	9.9	0.011	10.9
27	89.4	0.108	104.4	36.2	0.043	42.7	28.3	0.033	18.9	16.5	0.022	18.9	11.9	0.011	13.7

Building: **Single-family** **City: Massena** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,039.7	0.043								
13	1,201.9	0.054	162.3	0.011						
17	1,430.7	0.076	391.1	0.033	228.8	0.022				
19	1,514.0	0.076	474.3	0.033	312.1	0.022	83.2	0.000		
21	1,582.1	0.087	542.4	0.043	380.1	0.033	151.3	0.011	68.1	0.011
25	1,688.9	0.098	649.3	0.054	487.0	0.043	258.2	0.022	174.9	0.022
27	1,734.9	0.098	695.2	0.054	304.1	0.043	304.1	0.022	220.9	0.022

Building: **Single-family** **City: Massena** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,423.9	0.065								
13	1,651.2	0.076	227.3	0.011						
17	1,971.8	0.087	547.9	0.022	320.6	0.011				
19	2,089.2	0.098	665.3	0.033	438.0	0.022	117.4	0.011		
21	2,186.2	0.098	762.3	0.033	535.0	0.022	214.4	0.011	97.0	0.000
25	2,341.6	0.108	917.7	0.043	690.4	0.033	369.8	0.022	252.4	0.011
27	2,403.2	0.108	979.3	0.043	752.0	0.033	431.4	0.022	314.0	0.011

Building: Single-family City: Massena HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,400.7	00.0								
13	1,624.9	00.0	224.1	00.0						
17	1,940.3	00.0	539.6	00.0	315.4	00.0				
19	2,055.9	00.0	655.2	00.0	431.1	00.0	115.7	00.0		
21	2,152.1	00.0	751.4	00.0	527.2	00.0	211.8	00.0	96.1	00.0
25	2,303.6	00.0	902.9	00.0	678.7	00.0	363.3	00.0	247.7	00.0
27	2,364.8	00.0	964.1	00.0	740.0	00.0	424.6	00.0	308.9	00.0

Building: Single-family City: Massena HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	30.0	00.0	61.7												
13	34.9	00.0	71.5	4.9	00.0	9.9									
17	41.6	00.0	85.5	11.6	00.0	23.8	6.7	00.0	14.0						
19	44.1	00.0	90.7	14.1	00.0	29.0	9.2	00.0	19.2	2.5	00.0	5.2			
21	46.2	00.0	94.9	16.2	00.0	33.3	11.3	00.0	23.4	4.6	00.0	9.4	2.1	00.0	4.2
25	49.4	00.0	101.8	19.4	00.0	40.1	14.5	00.0	30.2	7.8	00.0	16.3	5.3	00.0	11.1
27	50.7	00.0	104.5	20.7	00.0	42.8	15.8	00.0	33.0	9.1	00.0	19.0	6.6	00.0	13.8

Building: Single-family City: Massena HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	338.4	0.290	381.2												
19	377.0	0.341	429.0	38.6	0.051	47.8									
30	400.2	0.375	457.2	61.8	0.085	75.9	23.2	0.034	28.2						
38	412.5	0.392	468.3	74.1	0.102	87.0	35.5	0.051	39.2	12.3	0.017	11.1			
49	420.6	0.392	477.8	82.3	0.102	96.6	43.7	0.051	48.8	20.5	0.017	20.6	8.2	0.000	9.6
60	426.3	0.410	484.1	87.9	0.119	102.9	49.3	0.068	55.1	26.1	0.034	27.0	13.8	0.017	15.9

Building: Single-family City: Massena HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,099.8	0.222								
19	7,936.3	0.273	836.5	0.051						
30	8,425.4	0.290	1,325.6	0.068	489.1	0.017				
38	8,614.0	0.307	1,514.2	0.085	677.6	0.034	188.6	0.017		
49	8,776.5	0.307	1,676.6	0.085	840.1	0.034	351.0	0.017	162.5	0.000
60	8,883.6	0.324	1,783.8	0.102	947.3	0.051	458.2	0.034	269.6	0.017

Building: Single-family City: Massena HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	9,089.2	0.290								
19	10,202.2	0.341	1,113.0	0.051						
30	10,854.3	0.375	1,765.0	0.085	652.0	0.034				
38	11,112.8	0.392	2,023.5	0.102	910.6	0.051	258.5	0.017		
49	11,336.0	0.392	2,246.8	0.102	1,133.8	0.051	481.7	0.017	223.2	0.000
60	11,481.7	0.410	2,392.5	0.119	1,279.5	0.068	627.5	0.034	368.9	0.017

Building: Single-family City: Massena HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	8,931.1	00.0								
19	10,027.6	00.0	1,096.6	00.0						
30	10,670.0	00.0	1,738.9	00.0	642.3	00.0				
38	10,921.5	00.0	1,990.4	00.0	893.9	00.0	251.5	00.0		
49	11,140.6	00.0	2,209.6	00.0	1,113.0	00.0	470.6	00.0	219.1	00.0
60	11,284.0	00.0	2,352.9	00.0	1,256.3	00.0	614.0	00.0	362.5	00.0

Building: Single-family City: Massena HVAC: Gas Heat, no AC Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	180.4	00.0	381.4												
19	202.9	00.0	429.2	22.5	00.0	47.8									
30	216.0	00.0	457.3	35.7	00.0	75.9	13.1	00.0	28.2						
38	221.3	00.0	468.4	41.0	00.0	87.0	18.4	00.0	39.2	5.3	00.0	11.1			
49	225.8	00.0	478.0	45.4	00.0	96.6	22.9	00.0	48.8	9.7	00.0	20.6	4.4	00.0	9.6
60	228.7	00.0	484.3	48.3	00.0	102.9	25.8	00.0	55.1	12.6	00.0	27.0	7.3	00.0	15.9

Building: Single-family City: NYC HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	60.0	0.054	36.6												
13	66.7	0.065	42.3	6.6	0.011	5.6									
17	80.6	0.076	50.6	20.6	0.022	14.0	14.0	0.011	8.3						
19	85.8	0.076	53.7	25.8	0.022	17.0	19.2	0.011	11.4	5.2	0.000	3.0			
21	90.1	0.076	56.1	30.0	0.022	19.5	23.4	0.011	13.9	9.4	0.000	5.5	4.2	0.000	2.5
25	95.5	0.087	60.2	35.4	0.033	23.5	28.8	0.022	17.9	14.8	0.011	9.5	9.6	0.011	6.5
27	97.8	0.087	61.7	37.7	0.033	25.0	31.1	0.022	11.1	17.1	0.011	11.1	11.9	0.011	8.0

Building: Single-family City: NYC HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	430.4	0.076								
13	493.8	0.087	63.4	0.011						
17	590.6	0.098	160.2	0.022	96.8	0.011				
19	626.1	0.108	195.6	0.033	132.2	0.022	35.4	0.011		
21	654.8	0.108	224.4	0.033	161.0	0.022	64.2	0.011	28.7	0.000
25	698.8	0.108	268.4	0.033	205.0	0.022	108.2	0.011	72.7	0.000
27	717.2	0.119	286.8	0.043	126.6	0.033	126.6	0.022	91.2	0.011

Building: Single-family City: NYC HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	840.8	0.054								
13	968.0	0.065	127.2	0.011						
17	1,158.0	0.076	317.3	0.022	190.0	0.011				
19	1,227.4	0.076	386.6	0.022	259.4	0.011	69.4	0.000		
21	1,284.8	0.076	444.1	0.022	316.8	0.011	126.8	0.000	57.4	0.000
25	1,374.3	0.087	533.5	0.033	406.2	0.022	216.2	0.011	146.9	0.011
27	1,410.1	0.087	569.4	0.033	442.1	0.022	252.1	0.011	182.7	0.011

Building: Single-family **City: NYC** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	798.1	00.0								
13	921.6	00.0	123.6	00.0						
17	1,101.2	00.0	303.2	00.0	179.6	00.0				
19	1,166.7	00.0	368.6	00.0	245.1	00.0	65.5	00.0		
21	1,221.5	00.0	423.5	00.0	299.9	00.0	120.3	00.0	54.8	00.0
25	1,307.6	00.0	509.5	00.0	386.0	00.0	206.4	00.0	140.9	00.0
27	1,341.6	00.0	543.6	00.0	420.0	00.0	240.4	00.0	174.9	00.0

Building: Single-family **City: NYC** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	17.2	00.0	36.7												
13	19.8	00.0	42.4	2.6	00.0	5.6									
17	23.7	00.0	50.6	6.5	00.0	13.9	3.9	00.0	8.2						
19	25.1	00.0	53.8	7.9	00.0	17.0	5.3	00.0	11.4	1.4	00.0	3.1			
21	26.3	00.0	56.3	9.1	00.0	19.5	6.5	00.0	13.9	2.6	00.0	5.6	1.2	00.0	2.5
25	28.3	00.0	60.3	11.1	00.0	23.5	8.5	00.0	17.9	4.6	00.0	9.6	3.1	00.0	6.5
27	29.0	00.0	61.8	11.8	00.0	25.0	9.2	00.0	19.4	5.3	00.0	11.2	3.9	00.0	8.0

Building: Single-family **City: NYC** **HVAC: AC with Gas Heat** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	415.2	0.307	224.4												
19	468.9	0.375	252.4	53.8	0.068	28.0									
30	497.8	0.392	268.6	82.6	0.085	44.2	28.8	0.017	16.2						
38	508.4	0.410	275.1	93.2	0.102	50.7	39.4	0.034	22.7	10.6	0.017	6.5			
49	515.2	0.410	280.5	100.0	0.102	56.1	46.2	0.034	28.2	17.4	0.017	11.9	6.8	0.000	5.5
60	521.8	0.427	284.1	106.7	0.119	59.7	52.9	0.051	31.7	24.1	0.034	15.5	13.5	0.017	9.0

Building: Single-family City: NYC HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	2,988.4	0.341								
19	3,333.1	0.410	344.7	0.068						
30	3 528.3	0.461	539.9	0.119	195.2	0.051				
38	3 604.4	0.478	616.0	0.137	271.3	0.068	76.1	0.017		
49	3,665.9	0.478	677.5	0.137	332.8	0.068	137.5	0.017	61.4	0.000
60	3,708.9	0.495	720.5	0.154	375.8	0.085	180.5	0.034	104.4	0.017

Building: Single-family City: NYC HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,338.7	0.307								
19	5,996.6	0.375	657.8	0.068						
30	6,373.9	0.392	1,035.2	0.085	377.3	0.017				
38	6,520.6	0.410	1,181.9	0.102	524.1	0.034	146.8	0.017		
49	6,646.8	0.410	1,308.0	0.102	650.2	0.034	272.9	0.017	126.1	0.000
60	6,731.1	0.427	1,392.3	0.119	734.5	0.051	357.2	0.034	210.4	0.017

Building: Single-family City: NYC HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,028.7	00.0								
19	5,645.6	00.0	616.9	00.0						
30	6,001.4	00.0	972.7	00.0	355.8	00.0				
38	6,140.8	00.0	1,112.1	00.0	495.2	00.0	139.4	00.0		
49	6,262.6	00.0	1,234.0	00.0	617.1	00.0	261.3	00.0	121.8	00.0
60	6,342.2	00.0	1,313.5	00.0	696.6	00.0	340.8	00.0	201.4	00.0

Building: Single-family City: NYC HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	105.6	00.0	224.4												
19	118.4	00.0	252.6	12.8	00.0	28.2									
30	125.9	00.0	268.8	20.3	00.0	44.4	7.5	00.0	16.2						
38	128.8	00.0	275.1	23.2	00.0	50.7	10.4	00.0	22.5	2.9	00.0	6.3			
49	131.4	00.0	280.7	25.8	00.0	56.3	13.0	00.0	28.2	5.5	00.0	11.9	2.6	00.0	5.6
60	133.1	00.0	284.3	27.5	00.0	59.9	14.7	00.0	31.7	7.2	00.0	15.5	4.3	00.0	9.2

Building: Single-family **City: Syracuse** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	49.2	0.033	51.4												
13	57.2	0.033	59.6	8.0	0.000	8.2									
17	72.6	0.043	71.2	23.4	0.011	19.8	15.4	0.011	11.6						
19	74.9	0.043	75.4	25.7	0.011	24.1	17.7	0.011	15.8	2.3	0.000	4.2			
21	79.4	0.043	79.0	30.2	0.011	27.6	22.2	0.011	19.4	6.8	0.000	7.8	4.6	0.000	3.6
25	84.5	0.054	84.5	35.3	0.022	33.2	27.3	0.022	24.9	11.9	0.011	13.3	9.6	0.011	9.1
27	88.0	0.054	86.8	38.8	0.022	35.4	30.8	0.022	15.6	15.4	0.011	15.6	13.1	0.011	11.4

Building: Single-family **City: Syracuse** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	760.8	0.033								
13	878.8	0.033	118.0	0.000						
17	1,046.2	0.043	285.4	0.011	167.4	0.011				
19	1,105.9	0.043	345.1	0.011	227.1	0.011	59.7	0.000		
21	1,154.8	0.043	394.0	0.011	276.0	0.011	108.6	0.000	48.9	0.000
25	1,233.0	0.054	472.3	0.022	354.2	0.022	186.9	0.011	127.1	0.011
27	1,265.8	0.054	505.0	0.022	219.6	0.022	219.6	0.011	159.9	0.011

Building: Single-family **City: Syracuse** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,175.9	0.033								
13	1,363.4	0.033	187.5	0.000						
17	1,631.7	0.043	455.8	0.011	268.3	0.011				
19	1,726.3	0.043	550.4	0.011	362.9	0.011	94.6	0.000		
21	1,807.7	0.043	631.8	0.011	444.3	0.011	176.0	0.000	81.4	0.000
25	1,933.8	0.054	757.9	0.022	570.3	0.022	302.1	0.011	207.5	0.011
27	1,985.6	0.054	809.7	0.022	622.2	0.022	353.9	0.011	259.3	0.011

Building: **Single-family** **City: Syracuse** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,151.6	00.0								
13	1,335.1	00.0	183.5	00.0						
17	1,593.5	00.0	441.9	00.0	258.4	00.0				
19	1,688.1	00.0	536.4	00.0	352.9	00.0	94.5	00.0		
21	1,766.6	00.0	615.0	00.0	431.5	00.0	173.1	00.0	78.6	00.0
25	1,890.3	00.0	738.7	00.0	555.2	00.0	296.8	00.0	202.3	00.0
27	1,939.7	00.0	788.1	00.0	604.6	00.0	346.2	00.0	251.7	00.0

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Building: Single-family **City: Syracuse** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	25.0	00.0	51.5												
13	29.0	00.0	59.6	4.0	00.0	8.1									
17	34.7	00.0	71.3	9.6	00.0	19.8	5.6	00.0	11.7						
19	36.7	00.0	75.5	11.7	00.0	24.1	7.7	00.0	15.9	2.1	00.0	4.2			
21	38.4	00.0	79.1	13.3	00.0	27.6	9.3	00.0	19.5	3.7	00.0	7.8	1.6	00.0	3.6
25	41.1	00.0	84.7	16.0	00.0	33.2	12.0	00.0	25.0	6.4	00.0	13.3	4.3	00.0	9.1
27	42.2	00.0	86.8	17.1	00.0	35.3	13.1	00.0	27.2	7.5	00.0	15.5	5.4	00.0	11.3

Building: Single-family **City: Syracuse** **HVAC: AC with Gas Heat** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	344.0	0.188	318.9												
19	384.3	0.205	357.8	40.3	0.017	38.9									
30	406.0	0.222	380.7	61.9	0.034	61.8	21.7	0.017	22.9						
38	416.4	0.239	389.8	72.4	0.051	70.8	32.1	0.034	31.9	10.4	0.017	9.0			
49	420.6	0.239	397.6	76.6	0.051	78.7	36.3	0.034	39.8	14.7	0.017	16.9	4.3	0.000	7.8
60	426.3	0.239	402.7	82.3	0.051	83.8	42.0	0.034	44.9	20.3	0.017	22.0	9.9	0.000	13.0

Building: Single-family **City: Syracuse** **HVAC: Heat Pump** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,539.8	0.188								
19	6,144.0	0.205	604.3	0.017						
30	6,488.6	0.222	948.8	0.034	344.5	0.017				
38	6,621.2	0.239	1,081.4	0.051	477.1	0.034	132.6	0.017		
49	6,737.4	0.239	1,197.6	0.051	593.3	0.034	248.8	0.017	116.2	0.000
60	6,813.0	0.256	1,273.2	0.068	668.9	0.051	324.4	0.034	191.8	0.017

Building: Single-family **City: Syracuse** **HVAC: AC with Electric Heat** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,544.0	0.188								
19	8,444.2	0.205	900.2	0.017						
30	8,970.3	0.222	1,426.3	0.034	526.1	0.017				
38	9,178.5	0.239	1,634.5	0.051	734.3	0.034	208.2	0.017		
49	9,355.3	0.239	1,811.3	0.051	911.1	0.034	385.0	0.017	176.8	0.000
60	9,473.7	0.239	1,929.7	0.051	1,029.5	0.034	503.4	0.017	295.2	0.000

Building: Single-family **City: Syracuse** **HVAC: Electric Heat, no AC** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7,354.6	00.0								
19	8,232.6	00.0	878.0	00.0						
30	8,747.6	00.0	1,393.0	00.0	515.0	00.0				
38	8,949.5	00.0	1,594.9	00.0	716.9	00.0	201.9	00.0		
49	9,125.8	00.0	1,771.2	00.0	893.2	00.0	378.2	00.0	176.3	00.0
60	9,241.0	00.0	1,886.3	00.0	1,008.4	00.0	493.3	00.0	291.5	00.0

Building: Single-family **City: Syracuse** **HVAC: Gas Heat No AC** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	154.4	00.0	318.9												
19	172.7	00.0	357.8	18.3	00.0	38.9									
30	183.3	00.0	380.7	28.8	00.0	61.8	10.6	00.0	22.9						
38	187.4	00.0	389.8	32.9	00.0	70.8	14.7	00.0	31.9	4.1	00.0	9.0			
49	191.1	00.0	397.6	36.7	00.0	78.7	18.4	00.0	39.8	7.8	00.0	16.9	3.8	00.0	7.8
60	193.5	00.0	402.7	39.1	00.0	83.8	20.8	00.0	44.9	10.2	00.0	22.0	6.1	00.0	13.0

Building: Single-family City: Binghamton HVAC: AC with Gas Heat Measure: Wall Insulation

0			11			13			17			19		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
46.2	0.043	54.0												
54.3	0.054	62.6	8.1	0.011	8.7									
64.3	0.065	74.8	18.1	0.022	20.8	10.0	0.011	12.1						
67.4	0.065	79.2	21.2	0.022	25.3	13.1	0.011	16.6	3.1	0.000	4.4			
71.0	0.076	82.9	24.8	0.033	28.9	16.7	0.022	20.3	6.7	0.011	8.1	3.6	0.011	3.7
75.4	0.076	88.7	29.3	0.033	34.7	21.1	0.022	26.0	11.2	0.011	13.9	8.0	0.011	9.4
77.5	0.076	90.9	31.3	0.033	37.0	23.2	0.022	16.2	13.2	0.011	16.2	10.1	0.011	11.7

Single-family City: Binghamton HVAC: Heat Pump Measure: Wall Insulation

0		11		13		17		19	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
846.0	0.054								
978.9	0.054	132.9	0.000						
1,165.7	0.065	319.7	0.011	186.9	0.011				
1,232.2	0.076	386.2	0.022	253.3	0.022	66.4	0.011		
1,288.1	0.076	442.1	0.022	309.2	0.022	122.4	0.011	55.9	0.000
1,374.2	0.087	528.2	0.033	395.3	0.033	208.4	0.022	142.0	0.011
1,407.8	0.087	561.8	0.033	242.0	0.033	242.0	0.022	175.6	0.011

Single-family City: Binghamton HVAC: AC with Electric Heat Measure: Wall Insulation

0		11		13		17		19	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
1,241.4	0.043								
1,440.0	0.054	198.6	0.011						
1,717.9	0.065	476.5	0.022	277.9	0.011				
1,818.7	0.065	577.3	0.022	378.7	0.011	100.8	0.000		
1,903.9	0.076	662.5	0.033	463.9	0.022	186.0	0.011	85.2	0.011
2,035.0	0.076	793.6	0.033	595.1	0.022	317.1	0.011	216.3	0.011
2,087.1	0.076	845.8	0.033	647.2	0.022	369.3	0.011	268.5	0.011

Single-family **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

0		11		13		17		19	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
1,222.6	00.0								
1,417.4	00.0	194.8	00.0						
1,691.4	00.0	468.8	00.0	274.0	00.0				
1,791.5	00.0	568.8	00.0	374.1	00.0	100.0	00.0		
1,874.9	00.0	652.3	00.0	457.5	00.0	183.5	00.0	83.5	00.0
2,004.4	00.0	781.8	00.0	587.0	00.0	313.0	00.0	213.0	00.0
2,055.6	00.0	833.0	00.0	638.2	00.0	364.2	00.0	264.1	00.0

City: Binghamton **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

0			11			13			17			19		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
27.3	00.0	54.0												
31.8	00.0	62.6	4.4	00.0	8.7									
37.8	00.0	74.8	10.5	00.0	20.8	6.1	00.0	12.1						
40.1	00.0	79.2	12.8	00.0	25.3	8.3	00.0	16.6	2.3	00.0	4.4			
41.9	00.0	82.9	14.6	00.0	28.9	10.2	00.0	20.3	4.1	00.0	8.1	1.8	00.0	3.7
44.9	00.0	88.7	17.6	00.0	34.7	13.1	00.0	26.0	7.0	00.0	13.9	4.8	00.0	9.4
46.0	00.0	90.9	18.6	00.0	37.0	14.2	00.0	28.3	8.1	00.0	16.2	5.9	00.0	11.7

City: Binghamton **HVAC: AC with Gas Heat** **Measure: Ceiling Insulation**

0			11			19			30			38		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
311.4	0.290	332.9												
350.9	0.341	374.4	39.4	0.051	41.5									
369.8	0.358	398.8	58.4	0.068	65.9	18.9	0.017	24.4						
377.1	0.375	408.2	65.7	0.085	75.3	26.3	0.034	33.8	7.3	0.017	9.4			
385.2	0.392	416.6	73.7	0.102	83.6	34.3	0.051	42.2	15.4	0.034	17.7	8.0	0.017	8.4
389.4	0.392	422.0	78.0	0.102	89.1	38.6	0.051	47.6	19.6	0.034	23.2	12.3	0.017	13.8

Single-family **City: Binghamton** **HVAC: Heat Pump** **Measure: Ceiling Insulation**

0		11		19		30		38	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
5,853.1	0.273								
6,534.8	0.324	681.7	0.051						
6,923.9	0.358	1,070.8	0.085	389.1	0.034				
7,075.4	0.358	1,222.4	0.085	540.6	0.034	151.5	0.000		
7,208.7	0.375	1,355.6	0.102	673.9	0.051	284.8	0.017	133.3	0.017
7,294.7	0.375	1,441.6	0.102	759.9	0.051	370.8	0.017	219.3	0.017

Single-family **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Ceiling Insulation**

0		11		19		30		38	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
7,921.3	0.290								
8,887.9	0.341	966.6	0.051						
9,449.0	0.358	1,527.6	0.068	561.1	0.017				
9,668.3	0.375	1,746.9	0.085	780.4	0.034	219.3	0.017		
9,861.9	0.392	1,940.6	0.102	974.1	0.051	413.0	0.034	193.7	0.017
9,987.0	0.392	2,065.7	0.102	1,099.1	0.051	538.1	0.034	318.8	0.017

Single-family **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Ceiling Insulation**

0		11		19		30		38	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
7,775.8	00.0								
8,723.0	00.0	947.3	00.0						
9,277.1	00.0	1,501.4	00.0	554.1	00.0				
9,493.9	00.0	1,718.1	00.0	770.8	00.0	216.7	00.0		
9,683.4	00.0	1,907.7	00.0	960.4	00.0	406.3	00.0	189.6	00.0
9,807.0	00.0	2,031.2	00.0	1,084.0	00.0	529.9	00.0	313.1	00.0

City: Binghamton **HVAC: Gas Heat No AC** **Measure: Ceiling Insulation**

0			11			19			30			38		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
166.0	00.0	333.1												
186.3	00.0	374.6	20.3	00.0	41.5									
198.1	00.0	398.8	32.1	00.0	65.7	11.8	00.0	24.2						
202.7	00.0	408.4	36.7	00.0	75.3	16.4	00.0	33.8	4.6	00.0	9.6			
206.8	00.0	416.7	40.8	00.0	83.6	20.5	00.0	42.2	8.7	00.0	17.9	4.1	00.0	8.4
209.4	00.0	422.2	43.3	00.0	89.1	23.0	00.0	47.6	11.3	00.0	23.4	6.7	00.0	13.8

Building: Single-family **City: Poughkeepsie** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	48.3	0.043	46.2												
13	53.4	0.054	53.8	5.1	0.011	7.6									
17	67.3	0.065	64.4	19.0	0.022	18.2	13.9	0.011	10.6						
19	71.0	0.065	68.3	22.7	0.022	22.1	17.6	0.011	14.5	3.7	0.000	3.9			
21	73.7	0.076	71.8	25.4	0.033	25.6	20.3	0.022	18.0	6.4	0.011	7.4	2.7	0.011	3.5
25	79.0	0.076	76.8	30.7	0.033	30.7	25.6	0.022	23.1	11.7	0.011	12.5	8.0	0.011	8.6
27	81.7	0.076	78.9	33.4	0.033	32.7	28.3	0.022	14.5	14.4	0.011	14.5	10.7	0.011	10.6

Building: **Single-family** **City: Poughkeepsie** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	591.6	0.054								
13	686.4	0.065	94.8	0.011						
17	823.1	0.076	231.5	0.022	136.7	0.011				
19	871.1	0.087	279.5	0.033	184.7	0.022	48.0	0.011		
21	914.8	0.087	323.2	0.033	228.4	0.022	91.7	0.011	43.7	0.000
25	978.4	0.098	386.8	0.043	292.0	0.033	155.3	0.022	107.3	0.011
27	1,004.0	0.098	412.4	0.043	180.9	0.033	180.9	0.022	132.9	0.011

Building: **Single-family** **City: Poughkeepsie** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,031.3	0.043								
13	1,197.2	0.054	165.8	0.011						
17	1,435.7	0.065	404.4	0.022	238.6	0.011				
19	1,521.5	0.065	490.1	0.022	324.3	0.011	85.7	0.000		
21	1,597.1	0.076	565.8	0.033	400.0	0.022	161.4	0.011	75.7	0.011
25	1,710.1	0.076	678.7	0.033	512.9	0.022	274.3	0.011	188.6	0.011
27	1,755.9	0.076	724.6	0.033	558.7	0.022	320.2	0.011	234.4	0.011

Building: Single-family City: Poughkeepsie HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,005.0	00.0								
13	1,169.5	00.0	164.5	00.0						
17	1,399.1	00.0	394.1	00.0	229.6	00.0				
19	1,483.0	00.0	478.0	00.0	313.5	00.0	83.9	00.0		
21	1,558.0	00.0	553.0	00.0	388.5	00.0	158.9	00.0	75.0	00.0
25	1,667.5	00.0	662.5	00.0	497.9	00.0	268.4	00.0	184.5	00.0
27	1,711.5	00.0	706.5	00.0	541.9	00.0	312.4	00.0	228.5	00.0

Building: Single-family City: Poughkeepsie HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	21.8	00.0	46.3												
13	25.4	00.0	53.8	3.6	00.0	7.5									
17	30.2	00.0	64.5	8.5	00.0	18.2	4.9	00.0	10.7						
19	32.1	00.0	68.4	10.3	00.0	22.1	6.7	00.0	14.6	1.8	00.0	3.9			
21	33.7	00.0	71.9	11.9	00.0	25.6	8.3	00.0	18.1	3.5	00.0	7.4	1.6	00.0	3.5
25	36.1	00.0	77.0	14.3	00.0	30.7	10.7	00.0	23.2	5.9	00.0	12.5	4.0	00.0	8.6
27	37.0	00.0	79.0	15.2	00.0	32.7	11.6	00.0	25.3	6.7	00.0	14.5	4.9	00.0	10.6

Building: Single-family City: Poughkeepsie HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	333.4	0.410	297.6												
19	374.6	0.461	335.5	41.1	0.051	37.9									
30	393.0	0.478	357.8	59.6	0.068	60.2	18.4	0.017	22.4						
38	402.7	0.495	366.7	69.3	0.085	69.1	28.2	0.034	31.2	9.7	0.017	8.9			
49	411.8	0.495	374.6	78.3	0.085	77.0	37.2	0.034	39.1	18.8	0.017	16.7	9.0	0.000	7.8
60	416.7	0.512	379.5	83.3	0.102	81.9	42.2	0.051	44.0	23.7	0.034	21.7	14.0	0.017	12.8

Building: Single-family **City:** Poughkeepsie **HVAC:** Heat Pump **Measure:** Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,368.1	0.444								
19	4,865.2	0.512	497.1	0.068						
30	5,151.0	0.529	782.9	0.085	285.8	0.017				
38	5,265.7	0.546	897.6	0.102	400.5	0.034	114.7	0.017		
49	5,364.7	0.563	996.6	0.119	499.5	0.051	213.7	0.034	99.0	0.017
60	5,427.1	0.563	1,059.0	0.119	561.9	0.051	276.1	0.034	161.4	0.017

Building: Single-family **City:** Poughkeepsie **HVAC:** AC with Electric Heat **Measure:** Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6,888.1	0.410								
19	7,742.8	0.461	854.8	0.051						
30	8,240.6	0.478	1,352.6	0.068	497.8	0.017				
38	8,439.1	0.495	1,551.0	0.085	696.2	0.034	198.5	0.017		
49	8,613.3	0.495	1,725.3	0.085	870.5	0.034	372.7	0.017	174.2	0.000
60	8,725.8	0.512	1,837.7	0.102	982.9	0.051	485.2	0.034	286.7	0.017

Building: Single-family **City:** Poughkeepsie **HVAC:** Electric Heat, no AC **Measure:** Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6,694.7	00.0								
19	7,526.8	00.0	832.1	00.0						
30	8,017.2	00.0	1,322.5	00.0	490.4	00.0				
38	8,209.6	00.0	1,514.8	00.0	682.8	00.0	192.3	00.0		
49	8,376.8	00.0	1,682.1	00.0	850.0	00.0	359.6	00.0	167.2	00.0
60	8,486.9	00.0	1,792.2	00.0	960.1	00.0	469.6	00.0	277.3	00.0

Building: Single-family **City:** Poughkeepsie **HVAC:** Gas Heat No AC **Measure:** Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm / kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm / kSF
11	140.8	00.0	297.6												
19	158.4	00.0	335.5	17.6	00.0	37.9									
30	168.6	00.0	358.0	27.8	00.0	60.4	10.2	00.0	22.5						
38	172.5	00.0	366.7	31.7	00.0	69.1	14.2	00.0	31.2	3.9	00.0	8.7			
49	176.1	00.0	374.4	35.3	00.0	76.8	17.7	00.0	38.9	7.5	00.0	16.4	3.6	00.0	7.7
60	178.3	00.0	379.5	37.5	00.0	81.9	20.0	00.0	44.0	9.7	00.0	21.5	5.8	00.0	12.8

MULTI-FAMILY LOW-RISE INSULATION UPGRADES

Building: Multi-Family Low-rise City: Albany HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	44.5	0.046	61.0												
13	57.4	0.057	80.7	13.0	0.011	19.7									
17	77.2	0.069	108.7	32.7	0.023	47.7	19.7	0.011	28.0						
19	84.5	0.080	119.0	40.0	0.034	58.0	27.1	0.023	38.3	7.3	0.011	10.3			
21	87.9	0.080	128.0	43.5	0.034	67.0	30.5	0.023	47.2	10.8	0.011	19.3	3.4	0.000	8.9
25	99.0	0.092	141.7	54.5	0.046	80.7	41.5	0.034	61.0	21.8	0.023	33.0	14.4	0.011	22.7
27	100.9	0.092	147.2	56.4	0.046	86.2	43.5	0.034	66.5	23.7	0.023	38.5	16.4	0.011	28.2

Building: Multi-Family Low-rise City: Albany HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	764.5	0.000								
13	1,010.1	0.011	245.6	0.000						
17	1,348.0	0.034	583.5	0.023	337.9	0.000				
19	1,472.4	0.034	707.9	0.023	462.3	0.000	124.4	0.000		
21	1,577.3	0.034	812.9	0.023	567.3	0.000	229.3	0.000	104.9	0.000
25	1,743.4	0.046	978.9	0.034	733.3	0.011	395.4	0.011	271.0	0.000
27	1,809.9	0.046	1,045.4	0.034	799.8	0.011	461.9	0.011	337.5	0.000

Building: Multi-Family Low-rise City: Albany HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	989.8	0.000								
13	1,301.1	0.011	311.3	0.000						
17	1,740.6	0.023	750.8	0.011	439.5	0.000				
19	1,901.3	0.034	911.5	0.023	600.2	0.011	160.6	0.000		
21	2,032.9	0.034	1,043.1	0.023	731.8	0.011	292.3	0.000	131.6	0.000
25	2,245.8	0.046	1,256.0	0.034	944.7	0.023	505.2	0.011	344.6	0.000
27	2,328.6	0.046	1,338.8	0.034	1,027.5	0.023	588.0	0.011	427.4	0.000

Building: Multi-Family Low-rise City: Albany HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	980.4	0.0								
13	1,289.9	0.0	309.5	0.0						
17	1,724.5	0.0	744.1	0.0	434.6	0.0				
19	1,883.4	0.0	903.0	0.0	593.5	0.0	158.9	0.0		
21	2,015.5	0.0	1,035.1	0.0	725.6	0.0	291.0	0.0	132.1	0.0
25	2,226.0	0.0	1,245.6	0.0	936.1	0.0	501.5	0.0	342.6	0.0
27	2,309.6	0.0	1,329.2	0.0	1,019.7	0.0	585.1	0.0	426.2	0.0

Building: Multi-Family Low-rise City: Albany HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	35.1	0.0	61.0												
13	46.2	0.0	80.7	11.1	0.0	19.7									
17	60.9	0.0	108.7	25.8	0.0	47.7	14.7	0.0	28.0						
19	66.5	0.0	119.0	31.4	0.0	58.0	20.3	0.0	38.3	5.6	0.0	10.3			
21	70.4	0.0	128.0	35.3	0.0	67.0	24.2	0.0	47.2	9.5	0.0	19.3	3.9	0.0	8.9
25	79.3	0.0	141.7	44.3	0.0	80.7	33.1	0.0	61.0	18.5	0.0	33.0	12.8	0.0	22.7
27	82.1	0.0	147.2	47.0	0.0	86.2	35.9	0.0	66.5	21.2	0.0	38.5	15.6	0.0	28.2

Building: Multi-Family Low-rise City: Albany HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	344.6	0.351	253.9												
19	406.0	0.413	301.5	61.3	0.061	47.6									
30	443.0	0.448	332.1	98.4	0.097	78.2	37.1	0.035	30.6						
38	459.5	0.466	344.5	114.8	0.114	90.6	53.5	0.053	43.0	16.4	0.018	12.4			
49	473.2	0.483	355.8	128.5	0.132	101.9	67.2	0.070	54.3	30.1	0.035	23.7	13.7	0.018	11.3
60	481.1	0.492	363.2	136.4	0.141	109.3	75.1	0.079	61.7	38.0	0.044	31.1	21.6	0.026	18.7

Building: **Multi-Family Low-rise** **City: Albany** **HVAC: Heat Pump** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,386.5	0.343								
19	5,086.8	0.404	700.3	0.061						
30	5,517.8	0.439	1,131.3	0.097	431.0	0.035				
38	5,694.0	0.448	1,307.6	0.105	607.2	0.044	176.2	0.009		
49	5,849.7	0.466	1,463.2	0.123	762.9	0.061	331.9	0.026	155.7	0.018
60	5,952.4	0.474	1,565.9	0.132	865.6	0.070	434.6	0.035	258.4	0.026

Building: **Multi-Family Low-rise** **City: Albany** **HVAC: AC with Electric Heat** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,034.2	0.351								
19	5,883.8	0.413	849.6	0.061						
30	6,408.2	0.448	1,374.0	0.097	524.4	0.035				
38	6,620.8	0.466	1,586.6	0.114	737.0	0.053	212.6	0.018		
49	6,809.0	0.483	1,774.8	0.132	925.2	0.070	400.9	0.035	188.3	0.018
60	6,933.1	0.492	1,899.0	0.141	1,049.4	0.079	525.0	0.044	312.4	0.026

Building: **Multi-Family Low-rise** **City: Albany** **HVAC: Electric Heat, no AC** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,849.7	0.0								
19	5,667.1	0.0	817.4	0.0						
30	6,173.5	0.0	1,323.8	0.0	506.4	0.0				
38	6,375.7	0.0	1,526.0	0.0	708.6	0.0	202.2	0.000		
49	6,558.3	0.0	1,708.6	0.0	891.2	0.0	384.8	0.000	182.6	0.0
60	6,678.5	0.0	1,828.8	0.0	1,011.3	0.0	505.0	0.000	302.7	0.0

Building: Multi-Family Low-rise **City: Albany** **HVAC: Gas Heat No AC** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	160.2	0.0	253.9												
19	189.3	0.0	301.5	29.2	0.0	47.6									
30	208.4	0.0	332.1	48.2	0.0	78.2	19.1	0.0	30.6						
38	214.5	0.0	344.5	54.4	0.0	90.6	25.2	0.0	43.0	6.1	0.0	12.4			
49	222.4	0.0	355.8	62.3	0.0	101.9	33.1	0.0	54.3	14.1	0.0	23.7	7.9	0.0	11.3
60	226.5	0.0	363.2	66.3	0.0	109.3	37.2	0.0	61.7	18.1	0.0	31.1	11.9	0.0	18.7

Building: Multi-Family Low-rise **City: Buffalo** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	35.3	0.023	61.7												
13	48.8	0.023	81.0	13.5	0.000	19.3									
17	62.5	0.034	107.7	27.2	0.011	46.0	13.6	0.011	26.7						
19	67.7	0.034	117.5	32.3	0.011	55.8	18.8	0.011	36.6	5.2	0.000	9.9			
21	72.6	0.046	125.8	37.3	0.023	64.1	23.7	0.023	44.8	10.1	0.011	18.1	4.9	0.011	8.3
25	80.5	0.046	139.1	45.2	0.023	77.4	31.6	0.023	58.1	18.0	0.011	31.4	12.8	0.011	21.6
27	83.7	0.046	144.5	48.4	0.023	82.8	34.9	0.023	63.5	21.2	0.011	36.8	16.1	0.011	26.9

Building: **Multi-Family Low-rise** **City: Buffalo** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	760.8	0.000								
13	1,005.4	0.000	244.6	0.000						
17	1,336.9	0.011	576.1	0.011	331.5	0.000				
19	1,457.6	0.011	696.8	0.011	452.2	0.000	120.7	0.000		
21	1,557.4	0.011	796.6	0.011	552.0	0.000	220.5	0.000	99.8	0.000
25	1,716.5	0.023	955.7	0.023	711.2	0.011	379.7	0.011	258.9	0.000
27	1,781.2	0.023	1,020.4	0.023	775.8	0.011	444.3	0.011	323.6	0.000

Building: **Multi-Family Low-rise** **City: Buffalo** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	964.0	0.000								
13	1,275.2	0.000	311.2	0.000						
17	1,698.2	0.011	734.2	0.011	423.0	0.000				
19	1,852.5	0.011	888.5	0.011	577.3	0.000	154.3	0.000		
21	1,982.3	0.023	1,018.3	0.023	707.1	0.011	284.1	0.011	129.8	00.000
25	2,187.0	0.023	1,223.0	0.023	911.8	0.011	488.8	0.011	334.5	00.000
27	2,268.8	0.023	1,304.8	0.023	993.6	0.011	570.6	0.011	416.2	00.000

Building: Multi-Family Low-rise City: Buffalo HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	960.2	0.000								
13	1,267.2	0.000	307.0	0.000						
17	1,690.7	-0.023	730.5	-0.023	423.6	0.000				
19	1,843.7	0.000	883.5	0.000	576.5	0.023	153.0	0.000		
21	1,975.5	0.000	1015.3	0.000	708.3	0.023	284.7	0.000	131.8	00.000
25	2,177.4	-0.023	1217.2	-0.023	910.2	0.000	486.6	-0.023	333.7	00.000
27	2,260.1	0.000	1299.9	0.000	992.9	0.023	569.3	0.000	416.4	00.000

Building: Multi-Family Low-rise City: Buffalo HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	31.5	0.000	61.7												
13	40.8	0.000	81.0	9.3	0.000	19.3									
17	55.2	-0.023	107.7	23.6	-0.023	46.0	14.3	0.000	26.7						
19	58.7	0.000	117.5	27.2	0.000	55.8	17.9	0.023	36.6	3.6	0.000	9.9			
21	65.8	0.000	125.8	34.3	0.000	64.1	25.0	0.023	44.8	10.7	0.000	18.1	7.1	0.000	8.3
25	70.9	-0.023	139.1	39.3	-0.023	77.4	30.0	0.000	58.1	15.7	-0.023	31.4	12.2	0.000	21.6
27	74.9	0.000	144.5	43.3	0.000	82.8	34.1	0.023	63.5	19.7	0.000	36.8	16.2	0.000	26.9

Building: Multi-Family Low-rise City: Buffalo HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	283.9	0.193	255.7												
19	332.8	0.237	302.5	48.8	0.044	46.7									
30	364.2	0.246	332.2	80.3	0.053	76.4	31.5	0.009	29.7						
38	377.1	0.255	344.2	93.1	0.061	88.5	44.3	0.018	41.7	12.8	0.009	12.0			
49	387.5	0.272	354.8	103.6	0.079	99.1	54.7	0.035	52.4	23.3	0.026	22.7	10.5	0.018	10.6
60	394.8	0.272	361.9	110.9	0.079	106.2	62.0	0.035	59.5	30.6	0.026	29.8	17.7	0.018	17.7

Building: Multi-Family Low-rise | City: Buffalo | HVAC: Heat Pump | Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,262.2	0.193								
19	4,950.5	0.228	688.3	0.035						
30	5,361.6	0.246	1,099.4	0.053	411.1	0.018				
38	5,525.9	0.246	1,263.6	0.053	575.3	0.018	164.3	0.000		
49	5,670.6	0.255	1,408.4	0.061	720.1	0.026	309.1	0.009	144.8	0.009
60	5,769.6	0.264	1,507.3	0.070	819.0	0.035	408.0	0.018	243.7	0.018

Building: Multi-Family Low-rise | City: Buffalo | HVAC: AC with Electric Heat | Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,017.6	0.193								
19	5,846.5	0.237	829.0	0.044						
30	6,357.2	0.246	1,339.6	0.053	510.7	0.009				
38	6,562.5	0.255	1,544.9	0.061	716.0	0.018	205.3	0.009		
49	6,743.3	0.272	1,725.7	0.079	896.8	0.035	386.1	0.026	180.8	0.018
60	6,862.8	0.272	1,845.2	0.079	1,016.3	0.035	505.6	0.026	300.3	0.018

Building: Multi-Family Low-rise | City: Buffalo | HVAC: Electric Heat, no AC | Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,884.2	0.000								
19	5,690.2	-0.044	806.0	0.000						
30	6,186.5	-0.018	1,302.3	0.026	496.3	0.000				
38	6,385.3	-0.018	1,501.1	0.026	695.1	0.000	198.8	0.000		
49	6,561.2	-0.018	1,677.0	0.026	870.9	0.000	374.7	0.000	175.9	0.000
60	6,677.4	-0.018	1,793.2	0.026	987.2	0.000	490.9	0.000	292.1	0.000

Building: Multi-Family Low-rise | City: Buffalo | HVAC: Gas Heat No AC | Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	150.6	0.000	255.7												
19	176.6	-0.044	302.5	26.0	0.000	46.7									
30	193.6	-0.018	332.2	43.0	0.026	76.4	17.0	0	29.7						
38	199.9	-0.018	344.2	49.3	0.026	88.5	23.3	0	41.7	6.2	0	12.0			
49	205.4	-0.018	354.8	54.8	0.026	99.1	28.8	0	52.4	11.8	0	22.7	5.5	0.000	10.6
60	209.4	-0.018	361.9	58.9	0.026	106.2	32.9	0	59.5	15.8	0	29.8	9.6	0.000	17.7

Building: Multi-Family Low-rise City: Massena HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	43.1	0.034	68.1												
13	56.8	0.046	90.7	13.6	0.011	22.6									
17	77.3	0.057	122.9	34.2	0.023	54.8	20.5	0.011	32.2						
19	83.0	0.069	134.6	39.9	0.034	66.5	26.3	0.023	43.9	5.7	0.011	11.7			
21	87.9	0.069	144.1	44.8	0.034	76.0	31.2	0.023	53.4	10.7	0.011	21.2	4.9	0.000	9.5
25	96.4	0.080	159.7	53.3	0.046	91.6	39.7	0.034	69.0	19.1	0.023	36.8	13.4	0.011	25.1
27	100.4	0.080	166.0	57.3	0.046	97.9	43.7	0.034	75.3	23.2	0.023	43.1	17.4	0.011	31.4

Building: Multi-Family Low-rise City: Massena HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	933.6	0.000								
13	1,229.6	0.011	296.0	0.000						
17	1,645.5	0.023	711.8	0.011	415.9	0.000				
19	1,795.1	0.034	861.5	0.023	565.5	0.011	149.6	0.000		
21	1,921.3	0.034	987.7	0.023	691.8	0.011	275.9	0.000	126.2	00.000
25	2,118.2	0.046	1,184.6	0.034	888.7	0.023	472.8	0.011	323.1	00.000
27	2,195.4	0.046	1,261.8	0.034	965.8	0.023	549.9	0.011	400.3	0.000

Building: Multi-Family Low-rise City: Massena HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,142.6	0.000								
13	1,504.5	0.011	361.9	0.000						
17	2,034.9	0.023	892.2	0.011	530.3	0.000				
19	2,219.4	0.034	1,076.7	0.023	714.8	0.011	184.5	0.000		
21	2,373.1	0.034	1,230.5	0.023	868.6	0.011	338.3	0.000	153.8	00.000
25	2,616.9	0.046	1,474.3	0.034	1,112.4	0.023	582.0	0.011	397.5	0.000
27	2,715.5	0.046	1,572.9	0.034	1,211.0	0.023	680.7	0.011	496.2	0.000

Building: Multi-Family Low-rise City: Massena HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,136.1	0.0								
13	1,496.4	0.0	360.3	0.0						
17	2,022.1	0.0	886.0	0.0	525.7	0.0				
19	2,206.7	0.0	1,070.6	0.0	710.4	00.0	184.6	00.0		
21	2,362.3	0.0	1,226.2	0.0	866.0	00.0	340.2	00.0	155.6	00.0
25	2,604.1	0.0	1,468.0	0.0	1,107.7	00.0	581.9	00.0	397.3	00.0
27	2,703.2	0.0	1,567.1	0.0	1,206.9	00.0	681.1	00.0	496.5	00.0

Building: Multi-Family Low-rise City: Massena HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	36.2	0	68.1												
13	48.2	0	90.7	11.9	0	22.6									
17	64.4	0	122.8	28.2	0	54.7	16.3	0	32.1						
19	70.6	0	134.5	34.4	0	66.4	22.5	0	43.8	6.2	0	11.7			
21	76.9	0	144.0	40.7	0	75.9	28.8	0	53.3	12.5	0	21.2	6.3	0.000	9.5
25	83.5	0	159.6	47.2	0	91.5	35.3	0	68.9	19.0	00	36.8	12.8	0.000	25.1
27	88.1	0	166.0	51.8	0	97.9	39.9	0	75.3	23.6	00	43.2	17.4	00.000	31.5

Building: Multi-Family Low-rise City: Massena HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	350.3	0.404	301.6												
19	414.3	0.466	357.2	64.0	0.061	55.6									
30	450.0	0.510	392.4	99.7	0.105	90.8	35.7	0.044	35.2						
38	466.7	0.527	406.7	116.4	0.123	105.2	52.4	0.061	49.5	16.7	0.018	14.3			
49	480.0	0.536	419.7	129.8	0.132	118.2	65.7	0.070	62.5	30.0	0.026	27.3	13.4	0.009	13.0
60	487.8	0.545	428.1	137.6	0.141	126.5	73.5	0.079	70.9	37.9	0.035	35.7	21.2	0.018	21.3

Building: Multi-Family Low-rise City: Massena HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,933.3	0.387								
19	6,907.4	0.457	974.1	0.070						
30	7,488.7	0.492	1,555.4	0.105	581.3	0.035				
38	7,715.0	0.501	1,781.7	0.114	807.6	0.044	226.3	0.009		
49	7,921.5	0.518	1,988.1	0.132	1,014.1	0.061	432.8	0.026	206.4	0.018
60	8,056.0	0.527	2,122.7	0.141	1,148.6	0.070	567.3	0.035	341.0	0.026

Building: Multi-Family Low-rise City: Massena HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6,004.7	0.404								
19	7,014.4	0.466	1,009.8	0.061						
30	7,635.5	0.510	1,630.9	0.105	621.1	0.044				
38	7,887.7	0.527	1,883.1	0.123	873.3	0.061	252.2	0.018		
49	8,110.2	0.536	2,105.5	0.132	1,095.8	0.070	474.7	0.026	222.4	0.009
60	8,255.6	0.545	2,251.0	0.141	1,241.2	0.079	620.1	0.035	367.9	0.018

Building: Multi-Family Low-rise City: Massena HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,829.0	0.000								
19	6,806.8	-0.026	977.8	0.000						
30	7,412.7	-0.044	1,583.7	-0.018	605.9	00.000				
38	7,655.7	-0.044	1,826.7	-0.018	848.9	00.000	243.0	0.000		
49	7,871.7	-0.044	2,042.6	-0.018	1,064.8	00.000	458.9	0.000	215.9	0.000
60	8,014.6	-0.044	2,185.5	-0.018	1,207.8	0.000	601.9	0.000	358.9	0.000

Building: Multi-Family Low-rise City: Massena HVAC: Gas Heat No AC Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	174.8	0.000	301.6												
19	206.7	-0.026	357.2	31.9	0.000	55.6									
30	227.2	-0.044	392.4	52.4	-0.018	90.8	20.5	0.000	35.2						
38	234.7	-0.044	406.7	59.9	-0.018	105.2	28.0	0.000	49.5	7.6	0.000	14.3			
49	241.8	-0.044	419.7	66.9	-0.018	118.1	35.1	0.000	62.5	14.6	0.000	27.2	7.0	0.000	12.9
60	247.0	-0.044	428.1	72.2	-0.018	126.5	40.3	0.000	70.9	19.9	0.000	35.7	12.3	0.000	21.3

Building: Multi-Family Low-rise City: NYC HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	37.8	0.034	44.1												
13	51.6	0.046	59.1	13.8	0.011	14.9									
17	70.1	0.069	78.9	32.2	0.034	34.7	18.5	0.023	19.8						
19	75.2	0.069	86.0	37.4	0.034	41.9	23.6	0.023	26.9	5.2	0.000	7.1			
21	79.3	0.080	92.1	41.5	0.046	47.9	27.7	0.034	33.0	9.3	0.011	13.2	4.1	0.011	6.1
25	88.5	0.080	101.6	50.7	0.046	57.4	36.9	0.034	42.5	18.5	0.011	22.7	13.3	0.011	15.6
27	90.8	0.080	105.1	53.0	0.046	61.0	39.2	0.034	46.1	20.8	0.011	26.3	15.6	0.011	19.1

Building: Multi-Family Low-rise City: NYC HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	469.7	0.000								
13	618.2	0.011	148.5	0.000						
17	832.5	0.023	362.8	0.011	214.3	0.000				
19	908.6	0.023	438.9	0.011	290.4	0.000	76.1	0.000		
21	971.4	0.034	501.8	0.023	353.3	0.011	139.0	0.011	62.8	0.000
25	1,070.9	0.034	601.2	0.023	452.7	0.011	238.4	0.011	162.3	0.000
27	1,104.2	0.046	634.6	0.034	486.1	0.023	271.8	0.023	195.6	0.000

Building: Multi-Family Low-rise City: NYC HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	687.5	0.000								
13	905.2	0.011	217.6	0.000						
17	1,210.0	0.034	522.4	0.023	304.8	0.000				
19	1,319.6	0.034	632.0	0.023	414.4	0.000	109.6	0.000		
21	1,411.0	0.046	723.4	0.034	505.8	0.011	201.0	0.011	91.4	0.000
25	1,557.0	0.046	869.5	0.034	651.9	0.011	347.1	0.011	237.5	0.000
27	1,603.8	0.046	916.3	0.034	698.7	0.011	393.9	0.011	284.3	0.000

Building: Multi-Family Low-rise City: NYC HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	673.1	0.0								
13	883.3	0.0	210.2	0.0						
17	1,178.3	0.0	505.2	0.0	295.0	0.0				
19	1,287.4	0.0	614.3	0.0	404.1	0.0	109.0	0.0		
21	1,375.9	0.0	702.8	0.0	492.6	0.0	197.6	0.0	88.5	0.0
25	1,518.4	0.0	845.3	0.0	635.1	0.0	340.1	0.0	231.1	0.0
27	1,564.3	0.0	891.2	0.0	681.0	0.0	386.0	0.0	276.9	0.0

Building: Multi-Family Low-rise City: NYC HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	23.4	0.0	44.1												
13	29.6	0.0	59.1	6.2	0.0	14.9									
17	38.3	0.0	78.9	14.9	0.0	34.7	8.7	0.0	19.8						
19	42.8	0.0	86.0	19.4	0.0	41.9	13.2	0.0	26.9	4.5	0.0	7.1			
21	44.3	0.0	92.1	20.9	00.0	47.9	14.7	0.0	33.0	6.0	0.0	13.2	1.5	0.0	6.1
25	49.9	0.0	101.7	26.5	00.0	57.6	20.3	0.0	42.7	11.6	0.0	22.8	7.1	0.0	15.7
27	51.1	0.0	105.1	27.7	0.0	61.0	21.6	0.0	46.1	12.8	0.0	26.3	8.4	0.0	19.1

Building: Multi-Family Low-rise City: NYC HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	372.7	0.369	181.6												
19	436.9	0.430	214.3	64.2	0.061	32.7									
30	475.4	0.466	235.4	102.7	0.097	53.9	38.5	0.035	21.2						
38	491.4	0.483	243.9	118.8	0.114	62.3	54.6	0.053	29.6	16.1	0.018	8.4			
49	505.1	0.492	251.0	132.4	0.123	69.4	68.2	0.061	36.7	29.7	0.026	15.5	13.6	0.009	7.1
60	514.9	0.501	256.1	142.2	0.132	74.5	78.0	0.070	41.8	39.5	0.035	20.6	23.5	0.018	12.2

Building: Multi-Family Low-rise City: NYC HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	2,594.7	0.351								
19	3,016.6	0.413	421.9	0.061						
30	3,275.1	0.448	680.5	0.097	258.5	0.035				
38	3,379.9	0.466	785.2	0.114	363.3	0.053	104.7	0.018		
49	3,472.5	0.474	877.8	0.123	455.9	0.061	197.3	0.026	92.6	0.009
60	3,531.2	0.483	936.6	0.132	514.6	0.070	256.1	0.035	151.4	0.018

Building: Multi-Family Low-rise City: NYC HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3,591.8	0.369								
19	4,183.7	0.430	591.8	0.061						
30	4,546.3	0.466	954.5	0.097	362.6	0.035				
38	4,692.6	0.483	1,100.8	0.114	508.9	0.053	146.3	0.018		
49	4,822.2	0.492	1,230.3	0.123	638.5	0.061	275.8	0.026	129.6	0.009
60	4,908.4	0.501	1,316.5	0.132	724.7	0.070	362.0	0.035	215.8	0.018

Building: Multi-Family Low-rise City: NYC HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3,350.2	0.0								
19	3,900.6	0.0	550.5	0.0						
30	4,238.8	0.0	888.6	0.0	338.1	0.0				
38	4,375.1	0.0	1,024.9	0.0	474.5	0.0	136.3	0.0		
49	4,495.1	0.0	1,145.0	0.0	594.5	0.0	256.3	0.0	120.0	0.0
60	4,574.6	0.0	1,224.5	0.0	674.0	0.0	335.9	0.0	199.5	0.0

Building: Multi-Family Low-rise City: NYC HVAC: Gas Heat No AC Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
1,	131.1	0.0	181.6												
19	153.9	0.0	214.3	22.8	00.0	32.7									
30	167.7	0.0	235.4	36.6	00.0	53.9	13.8	00.0	21.2						
38	173.9	0.0	243.9	42.9	00.0	62.3	20.0	00.0	29.6	6.2	00.0	8.4			
49	178.1	0.0	251.0	47.0	00.0	69.4	24.2	00.0	36.7	10.4	00.0	15.5	4.1	00.0	7.1
60	181.3	0.0	256.1	50.3	00.0	74.5	27.4	00.0	41.8	13.6	00.0	20.6	7.4	00.0	12.2

Building: Multi-Family Low-rise **City: Syracuse** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	44.8	0.034	61.3												
13	60.0	0.057	80.8	15.1	0.023	19.5									
17	79.1	0.069	108.5	34.3	0.034	47.1	19.1	0.011	27.6						
19	87.6	0.080	118.7	42.8	0.046	57.3	27.6	0.023	37.8	8.5	0.011	10.2			
21	93.7	0.092	127.5	48.8	0.057	66.2	33.7	0.034	46.7	14.6	0.023	19.0	6.1	0.011	8.8
25	103.4	0.092	140.9	58.6	0.057	79.6	43.5	0.034	60.1	24.3	0.023	32.5	15.8	0.011	22.2
27	106.9	0.103	146.5	62.0	0.069	85.2	46.9	0.046	65.7	27.7	0.034	38.1	19.3	0.023	27.9

Building: Multi-Family Low-rise **City: Syracuse** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	785.3	0.000								
13	1,030.8	0.011	245.5	0.000						
17	1380.9	0.034	595.6	0.023	350.1	0.000				
19	1,506.7	0.046	721.4	0.034	475.9	0.011	125.8	0.000		
21	1,613.9	0.046	828.6	0.034	583.1	0.011	233.0	0.000	107.2	00.000
25	1,780.3	0.057	995.0	0.046	749.5	0.023	399.4	0.011	273.6	00.000
27	1,847.5	0.057	1,062.1	0.046	816.6	0.023	466.6	0.011	340.8	00.000

Building: Multi-Family Low-rise **City: Syracuse** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,009.1	0.000								
13	1,328.2	0.023	319.1	0.000						
17	1,775.4	0.034	766.3	0.011	447.2	0.000				
19	1,940.4	0.046	931.3	0.023	612.2	0.011	165.0	0.000		
21	2,078.0	0.057	1,068.9	0.034	749.8	0.023	302.6	0.011	137.6	00.000
25	2,294.2	0.057	1,285.2	0.034	966.1	0.023	518.9	0.011	353.9	00.000
27	2,380.3	0.069	1,371.3	0.046	1,052.2	0.034	605.0	0.023	440.0	00.000

Building: Multi-Family Low-rise City: Syracuse HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,002.1	0.000								
13	1,316.7	0.000	314.6	0.000						
17	1,762.6	0.000	760.6	0.000	445.9	0.000				
19	1,924.7	0.000	922.6	0.000	608.0	0.000	162.0	0.000		
21	2,062.4	-0.023	1,060.3	-0.023	745.7	-0.023	299.7	-0.023	137.7	00.000
25	2,277.6	0.000	1,275.5	0.000	960.9	0.000	515.0	0.000	352.9	00.000
27	2,363.4	0.000	1,361.3	0.000	1,046.7	0.000	600.7	0.000	438.7	00.000

Building: Multi-Family Low-rise City: Syracuse HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	38.0	0.000	61.3												
13	48.4	0.000	80.8	10.4	0.000	19.5									
17	66.3	0.000	108.5	28.3	0.000	47.1	17.9	0.000	27.6						
19	71.9	0.000	118.7	33.9	0.000	57.3	23.5	0.000	37.8	5.6	0.000	10.2			
21	78.0	-0.023	127.5	40.0	-0.023	66.2	29.6	-0.023	46.7	11.7	-0.023	19.0	6.1	00.000	8.8
25	86.7	0.000	140.9	48.7	0.000	79.6	38.3	0.000	60.1	20.4	0.000	32.5	14.8	00.000	22.2
27	89.9	0.000	146.5	51.9	0.000	85.2	41.5	0.000	65.7	23.6	0.000	38.1	18.0	00.000	27.9

Building: Multi-Family Low-rise City: Syracuse HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	351.8	0.290	248.3												
19	414.0	0.351	294.7	62.1	0.061	46.5									
30	454.5	0.395	324.4	102.7	0.105	76.2	40.6	0.044	29.7						
38	470.3	0.413	337.3	118.4	0.123	89.0	56.3	0.061	42.5	15.7	0.018	12.8			
49	485.1	0.430	348.6	133.3	0.141	100.3	71.2	0.079	53.9	30.6	0.035	24.2	14.8	0.018	11.3
60	494.8	0.439	356.7	142.9	0.149	108.4	80.8	0.088	61.9	40.2	0.044	32.2	24.5	0.026	19.4

Building: Multi-Family Low-rise City: Syracuse HVAC: Heat Pump Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,182.6	0.290								
19	4,851.0	0.351	668.4	0.061						
30	5,270.0	0.387	1,087.3	0.097	419.0	0.035				
38	5,441.1	0.404	1,258.5	0.114	590.1	0.053	171.1	0.018		
49	5,593.8	0.422	1,411.1	0.132	742.8	0.070	323.8	0.035	152.7	0.018
60	5,693.9	0.430	1,511.3	0.141	842.9	0.079	424.0	0.044	252.8	0.026

Building: Multi-Family Low-rise City: Syracuse HVAC: AC with Electric Heat Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,874.3	0.290								
19	5,701.5	0.351	827.2	0.061						
30	6,220.2	0.395	1,345.9	0.105	518.7	0.044				
38	6,431.1	0.413	1,556.8	0.123	729.6	0.061	210.9	0.018		
49	6,620.7	0.430	1,746.4	0.141	919.2	0.079	400.5	0.035	189.6	0.018
60	6,745.7	0.439	1,871.4	0.149	1,044.2	0.088	525.5	0.044	314.6	0.026

Building: Multi-Family Low-rise City: Syracuse HVAC: Electric Heat, no AC Measure: Ceiling Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,685.6	0.000								
19	5,480.2	-0.044	794.6	0.000						
30	5,977.4	-0.044	1,291.8	0.000	497.2	0.000				
38	6,181.4	-0.061	1,495.8	-0.018	701.2	-0.018	204.0	0.000		
49	6,362.0	-0.061	1,676.4	-0.018	881.8	-0.018	384.6	0.000	180.6	0.000
60	6,481.5	-0.061	1,795.9	-0.018	1,001.3	-0.018	504.1	0.000	300.1	0.000

Building: Multi-Family Low-rise City: Syracuse HVAC: Gas Heat No AC Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	163.3	0.000	248.3												
19	192.7	-0.044	294.7	29.4	0.000	46.5									
30	211.9	-0.044	324.4	48.6	0.000	76.2	19.2	0.000	29.7						
38	220.7	-0.061	337.3	57.4	-0.018	89.0	27.9	-0.018	42.5	8.8	0.000	12.8			
49	226.7	-0.061	348.6	63.3	-0.018	100.3	33.9	-0.018	53.9	14.8	0.000	24.2	6.0	0.000	11.3
60	230.7	-0.061	356.7	67.4	-0.018	108.4	38.0	-0.018	61.9	18.8	0.000	32.2	10.0	0.000	19.4

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	41.6	0.023	62.8												
13	55.7	0.034	82.8	14.1	0.011	20.0									
17	73.2	0.046	112.0	31.5	0.023	49.2	17.4	0.011	29.2						
19	80.7	0.046	122.7	39.1	0.023	59.9	25.0	0.011	39.9	7.6	0.000	10.7			
21	87.5	0.046	132.1	45.9	0.023	69.3	31.8	0.011	49.3	14.3	0.000	20.1	6.8	0.000	9.4
25	96.2	0.057	146.5	54.6	0.034	83.7	40.5	0.023	63.8	23.0	0.011	34.5	15.5	0.011	23.9
27	99.8	0.057	152.2	58.1	0.034	89.3	44.0	0.023	69.4	26.6	0.011	40.1	19.0	0.011	29.5

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	791.9	0.000								
13	1,040.8	0.011	248.9	0.000						
17	1,395.4	0.023	603.5	0.011	354.5	0.000				
19	1,524.5	0.023	732.6	0.011	483.7	0.000	129.1	0.000		
21	1,633.2	0.023	841.3	0.011	592.4	0.000	237.8	0.000	108.7	0.000
25	1,802.5	0.034	1,010.7	0.023	761.7	0.011	407.2	0.011	278.1	0.000
27	1,869.7	0.034	1,077.9	0.023	828.9	0.011	474.4	0.011	345.3	0.000

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,019.7	0.000								
13	1,341.6	0.011	321.9	0.000						
17	1,793.1	0.023	773.4	0.011	451.6	0.000				
19	1,960.3	0.023	940.6	0.011	618.7	0.000	167.2	0.000		
21	2,101.1	0.023	1,081.4	0.011	759.5	0.000	308.0	0.000	140.8	0.000
25	2,319.2	0.034	1,299.5	0.023	977.6	0.011	526.1	0.011	358.9	0.000
27	2,406.7	0.034	1,387.0	0.023	1,065.1	0.011	613.6	0.011	446.4	0.000

Building: Multi-Family Low-rise City: Binghamton HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1,014.6	0.000								
13	1,333.0	0.000	318.4	0.000						
17	1,785.0	0.011	770.4	0.011	452.0	0.000				
19	1,950.6	0.011	936.0	0.011	617.6	0.000	165.6	0.000		
21	2,089.0	0.011	1,074.4	0.011	756.0	0.000	304.0	0.000	138.4	0.000
25	2,307.5	0.023	1,293.0	0.023	974.5	0.011	522.5	0.011	357.0	0.000
27	2,394.3	0.023	1,379.8	0.023	1,061.3	0.011	609.3	0.011	443.8	0.000

Building: Multi-Family Low-rise City: Binghamton HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	36.6	0.000	62.8												
13	47.1	0.000	82.8	10.5	0.000	20.0									
17	64.9	0.011	112.0	28.3	0.011	49.2	17.8	0.000	29.2						
19	71.2	0.011	122.7	34.6	0.011	59.9	24.1	0.000	39.9	6.3	0.000	10.7			
21	75.2	0.011	132.1	38.6	0.011	69.3	28.1	0.000	49.3	10.3	0.000	20.1	4.0	0.000	9.4
25	84.5	0.023	146.4	47.9	0.023	83.6	37.4	0.011	63.6	19.6	0.011	34.4	13.3	0.000	23.7
27	87.3	0.023	152.2	50.7	0.023	89.3	40.1	0.011	69.4	22.4	0.011	40.1	16.1	0.000	29.5

Building: Multi-Family Low-rise City: Binghamton HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	301.9	0.264	257.9												
19	356.6	0.307	306.3	54.7	0.044	48.4									
30	392.1	0.343	337.3	90.2	0.079	79.3	35.5	0.035	30.9						
38	404.6	0.351	350.3	102.7	0.088	92.4	48.0	0.044	44.0	12.5	0.009	13.1			
49	417.3	0.360	360.9	115.4	0.097	103.0	60.7	0.053	54.6	25.2	0.018	23.6	12.7	0.009	10.5
60	424.9	0.369	368.4	123.1	0.105	110.4	68.3	0.061	62.0	32.9	0.026	31.1	20.4	0.018	18.0

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: Heat Pump** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,382.6	0.255								
19	5,099.3	0.299	716.7	0.044						
30	5,544.9	0.334	1,162.3	0.079	445.7	0.035				
38	5,723.0	0.343	1,340.4	0.088	623.7	0.044	178.1	0.009		
49	5,881.2	0.351	1,498.6	0.097	782.0	0.053	336.3	0.018	158.2	0.009
60	5,987.4	0.360	1,604.8	0.105	888.2	0.061	442.5	0.026	264.4	0.018

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5,076.3	0.264								
19	5,946.5	0.307	870.2	0.044						
30	6,484.6	0.343	1,408.2	0.079	538.1	0.035				
38	6,698.7	0.351	1,622.3	0.088	752.2	0.044	214.1	0.009		
49	6,890.3	0.360	1,813.9	0.097	943.8	0.053	405.7	0.018	191.6	0.009
60	7,015.9	0.369	1,939.6	0.105	1,069.4	0.061	531.3	0.026	317.2	0.018

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,935.8	0.000								
19	5,778.6	0.018	842.8	0.000						
30	6,301.2	0.026	1,365.5	0.009	522.6	0.000				
38	6,510.2	0.026	1,574.5	0.009	731.6	0.000	209.0	0.000		
49	6,696.9	0.026	1,761.1	0.009	918.3	0.000	395.7	0.000	186.7	0.000
60	6,818.9	0.026	1,883.1	0.009	1,040.2	0.000	517.6	0.000	308.6	0.000

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: Gas Heat No AC** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	161.2	0.000	257.9												
19	188.5	0.018	306.3	27.3	0.000	48.4									
30	208.6	0.026	337.3	47.4	0.009	79.3	20.1	0.000	30.9						
38	215.9	0.026	350.3	54.7	0.009	92.4	27.4	0.000	44.0	7.3	0.000	13.1			
49	223.8	0.026	360.9	62.5	0.009	103.0	35.2	0.000	54.6	15.1	0.000	23.6	7.8	0.000	10.5
60	227.8	0.026	368.4	66.6	0.009	110.4	39.3	0.000	62.0	19.2	0.000	31.1	11.9	0.000	18.0

Building: Multi-Family Low-rise **City: Poughkeepsie** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	39.4	0.023	61.6												
13	53.3	0.023	81.6	13.9	0.000	20.1									
17	69.3	0.046	110.9	29.8	0.023	49.3	15.9	0.023	29.2						
19	77.4	0.046	121.8	38.0	0.023	60.2	24.1	0.023	40.1	8.1	0.000	10.9			
21	82.7	0.046	130.7	43.2	0.023	69.1	29.4	0.023	49.1	13.4	0.000	19.8	5.3	0.000	8.9
25	91.5	0.057	145.3	52.1	0.034	83.7	38.2	0.034	63.6	22.2	0.011	34.4	14.1	0.011	23.5
27	94.8	0.057	151.1	55.4	0.034	89.6	41.5	0.034	69.5	25.6	0.011	40.2	17.4	0.011	29.4

Building: **Multi-Family Low-rise** **City: Poughkeepsie** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	663.6	0.000								
13	873.5	0.011	210.0	0.000						
17	1,171.2	0.023	507.6	0.011	297.7	0.000				
19	1,284.4	0.023	620.8	0.011	410.8	0.000	113.2	0.000		
21	1,374.0	0.023	710.5	0.011	500.5	0.000	202.8	0.000	89.7	0.000
25	1,519.1	0.034	855.5	0.023	645.6	0.011	347.9	0.011	234.7	0.000
27	1,577.0	0.034	913.4	0.023	703.5	0.011	405.8	0.011	292.6	0.000

Building: **Multi-Family Low-rise** **City: Poughkeepsie** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	867.7	0.000								
13	1,144.5	0.000	276.8	0.000						
17	1,532.2	0.023	664.5	0.023	387.7	0.000				
19	1,676.5	0.023	808.9	0.023	532.0	0.000	144.4	0.000		
21	1,795.8	0.023	928.1	0.023	651.3	0.000	263.6	0.000	119.3	0.000
25	1,984.6	0.034	1,117.0	0.034	840.2	0.011	452.5	0.011	308.1	0.000
27	2,060.1	0.034	1,192.4	0.034	915.6	0.011	527.9	0.011	383.6	0.000

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	863.4	0.000								
13	1,137.9	0.000	274.5	0.000						
17	1,524.7	0.000	661.3	0.000	386.8	0.000				
19	1,666.8	0.023	803.3	0.023	528.8	0.023	142.1	0.000		
21	1,786.3	0.023	922.8	0.023	648.3	0.023	261.6	0.000	119.5	0.000
25	1,974.8	0.000	1,111.3	0.000	836.8	0.000	450.1	-0.023	308.0	0.000
27	2,050.5	0.000	1,187.0	0.000	912.5	0.000	525.7	-0.023	383.7	0.000

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	35.4	0.000	61.6												
13	47.0	0.000	81.8	11.6	0.000	20.2									
17	62.1	0.000	110.9	26.7	0.000	49.3	15.1	0.000	29.1						
19	67.9	0.023	121.8	32.5	0.023	60.2	20.9	0.023	40.0	5.7	0.000	10.9			
21	73.4	0.023	130.6	38.0	0.023	69.0	26.4	0.023	48.8	11.2	0.000	19.7	5.5	0.000	8.8
25	81.8	0.000	145.3	46.3	0.000	83.7	34.7	0.000	63.5	19.6	-0.023	34.4	13.9	0.000	23.5
27	85.2	0.000	151.2	49.8	0.000	89.7	38.2	0.000	69.5	23.0	-0.023	40.4	17.3	0.000	29.5

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: AC with Gas Heat Measure: Ceiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	357.2	0.343	246.5												
19	423.3	0.395	298.1	66.1	0.053	51.6									
30	464.6	0.430	332.0	107.4	0.088	85.5	41.3	0.035	33.9						
38	481.2	0.448	346.5	124.0	0.105	100.0	57.9	0.053	48.4	16.6	0.018	14.5			
49	495.7	0.457	359.4	138.5	0.114	112.9	72.5	0.061	61.3	31.2	0.026	27.4	14.6	0.009	12.9
60	504.6	0.466	368.1	147.4	0.123	121.6	81.3	0.070	70.0	40.1	0.035	36.1	23.5	0.018	21.6

Building: **Multi-Family Low-rise** **City: Poughkeepsie** **HVAC: Heat Pump** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3,838.4	0.334								
19	4,496.7	0.387	658.4	0.053						
30	4,908.8	0.422	1,070.5	0.088	412.1	0.035				
38	5,074.2	0.439	1,235.9	0.105	577.5	0.053	165.4	0.018		
49	5,221.4	0.448	1,383.0	0.114	724.7	0.061	312.6	0.026	147.1	0.009
60	5,317.8	0.448	1,479.4	0.114	821.0	0.061	408.9	0.026	243.5	0.009

Building: **Multi-Family Low-rise** **City: Poughkeepsie** **HVAC: AC with Electric Heat** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,482.9	0.343								
19	5,283.0	0.395	800.1	0.053						
30	5,783.2	0.430	1,300.3	0.088	500.2	0.035				
38	5,985.8	0.448	1,502.9	0.105	702.8	0.053	202.6	0.018		
49	6,165.8	0.457	1,682.9	0.114	882.8	0.061	382.6	0.026	180.0	0.009
60	6,284.3	0.466	1,801.4	0.123	1001.3	0.070	501.1	0.035	298.5	0.018

Building: **Multi-Family Low-rise** **City: Poughkeepsie** **HVAC: Electric Heat, no AC** **Measure: Ceiling Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4,298.9	0.000								
19	5,064.3	-0.018	765.4	0.000						
30	5,544.0	-0.018	1,245.1	0.000	479.7	0.000				
38	5,738.0	-0.018	1,439.2	0.000	673.7	0.000	194.1	0.000		
49	5,911.7	-0.018	1,612.8	0.000	847.4	0.000	367.7	0.000	173.7	0.000
60	6,026.6	-0.018	1,727.8	0.000	962.3	0.000	482.6	0.000	288.6	0.000

Building: Multi-Family Low-rise **City: Poughkeepsie** **HVAC: Gas Heat No AC** **Measure: Ceiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	173.1	0.000	246.5												
19	204.6	-0.018	298.1	31.5	0.000	51.6									
30	225.4	-0.018	332.0	52.4	0.000	85.5	20.8	0.000	33.9						
38	233.5	-0.018	346.5	60.4	0.000	100.0	28.9	0.000	48.4	8.1	0.000	14.5			
49	241.5	-0.018	359.5	68.4	0.000	113.0	36.9	0.000	61.4	16.1	0.000	27.5	8.0	0.000	13.0
60	246.8	-0.018	368.2	73.7	0.000	121.7	42.2	0.000	70.1	21.3	0.000	36.2	13.3	0.000	21.7

MULTI-FAMILY HIGH-RISE INSULATION UPGRADES

Building: Multi-Family High-rise **City:** Albany **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	14.6	0.008	51.3												
13	18.9	0.014	67.0	4.3	0.005	15.7									
17	24.7	0.016	88.9	10.1	0.008	37.5	5.8	0.003	21.8						
19	26.8	0.019	96.9	12.2	0.011	45.6	7.9	0.005	29.9	2.1	0.003	8.1			
21	28.5	0.022	103.6	13.9	0.014	52.2	9.6	0.008	36.5	3.8	0.005	14.7	1.7	0.003	6.6
25	31.0	0.022	113.5	16.3	0.014	62.2	12.0	0.008	46.5	6.2	0.005	24.7	4.2	0.003	16.6
27	32.0	0.024	117.6	17.4	0.016	66.3	13.1	0.011	50.6	7.3	0.008	28.7	5.2	0.005	20.7

Building: Multi-Family High-rise **City:** Albany **HVAC:** Chiller and Boiler with FPFC **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	138.1	0.254	411.4												
19	150.5	0.263	476.4	12.4	0.009	65.0									
30	156.8	0.281	515.6	18.8	0.026	104.2	6.3	0.018	39.2						
38	159.1	0.281	531.1	21.0	0.026	119.7	8.6	0.018	54.7	2.3	0.000	15.5			
49	160.9	0.298	545.2	22.9	0.044	133.9	10.4	0.035	68.8	4.1	0.018	29.6	1.8	0.018	14.1
60	162.1	0.307	554.7	24.0	0.053	143.3	11.6	0.044	78.3	5.3	0.026	39.1	3.0	0.026	23.6

Building: Multi-Family High-rise **City:** Albany **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	57.2												
13	0.0	0.0	74.7	0.0	0.0	17.5									
17	0.0	0.0	99.0	0.0	0.0	41.8	0.0	0.0	24.3						
19	0.0	0.0	108.0	0.0	0.0	50.8	0.0	0.0	33.3	0.0	0.0	9.0			
21	0.0	0.0	115.4	0.0	0.0	58.2	0.0	0.0	40.7	0.0	0.0	16.4	0.0	0.0	7.4
25	0.0	0.0	126.5	0.0	0.0	69.3	0.0	0.0	51.8	0.0	0.0	27.5	0.0	0.0	18.5
27	0.0	0.0	131.1	0.0	0.0	73.9	0.0	0.0	56.4	0.0	0.0	32.0	0.0	0.0	23.1

Building: Multi-Family High-rise **City:** Albany **HVAC:** Steam Boiler Only **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	458.4												
19	0.0	0.0	530.9	0.0	0.0	72.5									
30	0.0	0.0	574.5	0.0	0.0	116.1	0.0	0.0	43.7						
38	0.0	0.0	591.8	0.0	0.0	133.4	0.0	0.0	60.9	0.0	0.0	17.3			
49	0.0	0.0	607.5	0.0	0.0	149.2	0.0	0.0	76.7	0.0	0.0	33.0	0.0	0.0	15.7
60	0.0	0.0	618.1	0.0	0.0	159.7	0.0	0.0	87.2	0.0	0.0	43.6	0.0	0.0	26.3

Building: Multi-Family High-rise **City:** Buffalo **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	10.2	0.005	52.3												
13	13.2	0.008	68.8	3.0	0.003	16.5									
17	17.3	0.011	91.8	7.1	0.005	39.5	4.1	0.003	23.0						
19	18.7	0.011	100.0	8.5	0.005	47.7	5.5	0.003	31.2	1.4	0.000	8.2			
21	19.9	0.014	106.8	9.7	0.008	54.5	6.7	0.005	38.0	2.6	0.003	15.0	1.2	0.003	6.8
25	21.7	0.014	117.4	11.4	0.008	65.1	8.4	0.005	48.6	4.4	0.003	25.6	3.0	0.003	17.4
27	22.4	0.014	121.7	12.2	0.008	69.4	9.1	0.005	52.9	5.1	0.003	29.9	3.7	0.003	21.7

Building: Multi-Family High-rise **City:** Buffalo **HVAC:** Chiller and Boiler with FPFC **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	110.0	0.079	406.5												
19	117.0	0.105	468.2	7.0	0.026	61.7									
30	120.1	0.123	506.7	10.1	0.044	100.3	3.1	0.018	38.6						
38	121.0	0.131	521.7	11.0	0.053	115.2	3.9	0.026	53.5	0.9	0.009	14.9			
49	121.7	0.131	535.6	11.7	0.053	129.1	4.6	0.026	67.4	1.6	0.009	28.8	0.7	0.000	13.9
60	122.1	0.140	544.5	12.1	0.061	138.1	5.1	0.035	76.3	2.0	0.018	37.8	1.1	0.009	22.9

Building: Multi-Family High-rise **City:** Buffalo **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	58.3												
13	0.0	0.0	76.7	0.0	0.0	18.4									
17	0.0	0.0	102.3	0.0	0.0	44.0	0.0	0.0	25.6						
19	0.0	0.0	111.4	0.0	0.0	53.1	0.0	0.0	34.8	0.0	0.0	9.1			
21	0.0	0.0	119.0	0.0	0.0	60.7	0.0	0.0	42.4	0.0	0.0	16.7	0.0	0.0	7.6
25	0.0	0.0	130.8	0.0	0.0	72.5	0.0	0.0	54.1	0.0	0.0	28.5	0.0	0.0	19.4
27	0.0	0.0	135.6	0.0	0.0	77.3	0.0	0.0	59.0	0.0	0.0	33.3	0.0	0.0	24.2

Building: Multi-Family High-rise **City:** Buffalo **HVAC:** Steam Boiler Only **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	452.9												
19	0.0	0.0	521.7	0.0	0.0	68.8									
30	0.0	0.0	564.7	0.0	0.0	111.7	0.0	0.0	43.0						
38	0.0	0.0	581.3	0.0	0.0	128.3	0.0	0.0	59.6	0.0	0.0	16.6			
49	0.0	0.0	596.8	0.0	0.0	143.9	0.0	0.0	75.1	0.0	0.0	32.1	0.0	0.0	15.5
60	0.0	0.0	606.8	0.0	0.0	153.8	0.0	0.0	85.1	0.0	0.0	42.1	0.0	0.0	25.5

Building: Multi-Family High-rise **City:** Massena **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	17.9	0.016	61.3												
13	23.2	0.024	80.3	5.3	0.008	19.0									
17	30.5	0.033	106.3	12.6	0.016	45.0	7.3	0.008	26.0						
19	33.1	0.035	115.6	15.2	0.019	54.3	9.9	0.011	35.3	2.6	0.003	9.4			
21	35.3	0.038	123.6	17.4	0.022	62.3	12.1	0.014	43.3	4.8	0.005	17.3	2.2	0.003	8.0
25	38.6	0.041	136.0	20.8	0.024	74.7	15.4	0.016	55.7	8.1	0.008	29.7	5.5	0.005	20.3
27	40.0	0.044	140.9	22.1	0.027	79.6	16.8	0.019	60.6	9.5	0.011	34.6	6.9	0.008	25.3

Building: Multi-Family High-rise **City:** Massena **HVAC:** Chiller and Boiler with FPFC **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	130.3	0.149	481.9												
19	140.4	0.175	556.3	10.1	0.026	74.3									
30	145.5	0.193	601.4	15.2	0.044	119.5	5.1	0.018	45.1						
38	147.3	0.210	619.5	16.9	0.061	137.5	6.8	0.035	63.2	1.8	0.018	18.1			
49	148.8	0.219	635.5	18.4	0.070	153.6	8.3	0.044	79.2	3.2	0.026	34.1	1.5	0.009	16.0
60	149.5	0.228	645.7	19.2	0.079	163.7	9.1	0.053	89.4	4.0	0.035	44.3	2.3	0.018	26.2

Building: Multi-Family High-rise **City:** Massena **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	68.3												
13	0.0	0.0	89.5	0.0	0.0	21.2									
17	0.0	0.0	118.4	0.0	0.0	50.1	0.0	0.0	28.9						
19	0.0	0.0	128.9	0.0	0.0	60.5	0.0	0.0	39.4	0.0	0.0	10.4			
21	0.0	0.0	137.7	0.0	0.0	69.4	0.0	0.0	48.2	0.0	0.0	19.3	0.0	0.0	8.9
25	0.0	0.0	151.5	0.0	0.0	83.2	0.0	0.0	62.0	0.0	0.0	33.1	0.0	0.0	22.7
27	0.0	0.0	157.0	0.0	0.0	88.7	0.0	0.0	67.5	0.0	0.0	38.6	0.0	0.0	28.2

Building: Multi-Family High-rise **City:** Massena **HVAC:** Steam Boiler Only **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	537.0												
19	0.0	0.0	619.9	0.0	0.0	82.8									
30	0.0	0.0	670.2	0.0	0.0	133.1	0.0	0.0	50.3						
38	0.0	0.0	690.3	0.0	0.0	153.3	0.0	0.0	70.4	0.0	0.0	20.1			
49	0.0	0.0	708.1	0.0	0.0	171.1	0.0	0.0	88.3	0.0	0.0	38.0	0.0	0.0	17.9
60	0.0	0.0	719.5	0.0	0.0	182.5	0.0	0.0	99.6	0.0	0.0	49.3	0.0	0.0	29.2

Building: **Multi-Family High-rise** **City:** **NYC** **HVAC:** **Chiller and Boiler with FPFC** **Measure:** **Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	36.2	0.008	35.5												
13	47.2	0.011	46.2	11.0	0.003	10.7									
17	62.4	0.016	61.2	26.2	0.008	25.7	15.2	0.005	15.0						
19	67.9	0.016	66.5	31.7	0.008	30.9	20.6	0.005	20.3	5.5	0.000	5.2			
21	72.4	0.019	71.1	36.2	0.011	35.5	25.2	0.008	24.9	10.0	0.003	9.8	4.5	0.003	4.6
25	79.5	0.019	78.3	43.2	0.011	42.8	32.2	0.008	32.1	17.1	0.003	17.1	11.6	0.003	11.9
27	82.3	0.022	81.0	46.0	0.014	45.5	35.0	0.011	34.8	19.9	0.005	19.8	14.4	0.005	14.6

Building: **Multi-Family High-rise** **City:** **NYC** **HVAC:** **Chiller and Boiler with FPFC** **Measure:** **RCeiling Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	279.9	0.114	285.9												
19	315.5	0.149	333.4	35.6	0.035	47.5									
30	335.8	0.175	361.7	55.9	0.061	75.8	20.3	0.026	28.3						
38	343.6	0.184	373.5	63.7	0.070	87.7	28.1	0.035	40.1	7.8	0.009	11.8			
49	350.4	0.193	382.9	70.5	0.079	97.0	34.9	0.044	49.5	14.6	0.018	21.2	6.7	0.009	9.4
60	354.8	0.202	390.3	74.9	0.088	104.4	39.3	0.053	56.9	18.9	0.026	28.6	11.1	0.018	16.7

Building: **Multi-Family High-rise** **City:** **NYC** **HVAC:** **Steam Boiler Only** **Measure:** **Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	39.6												
13	0.0	0.0	51.5	0.0	0.0	11.9									
17	0.0	0.0	68.2	0.0	0.0	28.6	0.0	0.0	16.8						
19	0.0	0.0	74.1	0.0	0.0	34.5	0.0	0.0	22.6	0.0	0.0	5.8			
21	0.0	0.0	79.2	0.0	0.0	39.6	0.0	0.0	27.7	0.0	0.0	10.9	0.0	0.0	5.1
25	0.0	0.0	87.3	0.0	0.0	47.7	0.0	0.0	35.8	0.0	0.0	19.0	0.0	0.0	13.2
27	0.0	0.0	90.3	0.0	0.0	50.7	0.0	0.0	38.8	0.0	0.0	22.1	0.0	0.0	16.2

Building:	Multi-Family High-rise			City:	NYC		HVAC:	Steam Boiler Only				Measure:		RCeiling Insulation
Base	0			11			19			30			38	
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	318.5												
19	0.0	0.0	371.5	0.0	0.0	52.9									
30	0.0	0.0	403.0	0.0	0.0	84.5	0.0	0.0	31.5						
38	0.0	0.0	416.2	0.0	0.0	97.7	0.0	0.0	44.7	0.0	0.0	13.2			
49	0.0	0.0	426.6	0.0	0.0	108.1	0.0	0.0	55.2	0.0	0.0	23.6	0.0	0.0	10.5
60	0.0	0.0	434.9	0.0	0.0	116.3	0.0	0.0	63.4	0.0	0.0	31.8	0.0	0.0	18.7

Building:	Multi-Family High-rise			City:	Syracuse		HVAC:	Chiller and Boiler with FPFC				Measure:		Wall Insulation
Base	0			11			13			17			19	
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	16.1	0.014	50.6												
13	20.9	0.019	66.1	4.8	0.005	15.5									
17	27.4	0.024	87.7	11.2	0.011	37.1	6.5	0.005	21.6						
19	29.6	0.027	95.5	13.5	0.014	44.9	8.8	0.008	29.4	2.3	0.003	7.8			
21	31.5	0.030	102.0	15.4	0.016	51.4	10.6	0.011	35.9	4.2	0.005	14.3	1.9	0.003	6.4
25	34.4	0.033	112.5	18.3	0.019	61.8	13.5	0.014	46.3	7.0	0.008	24.7	4.8	0.005	16.9
27	35.5	0.033	116.8	19.4	0.019	66.2	14.7	0.014	50.7	8.2	0.008	29.1	5.9	0.005	21.3

Building:	Multi-Family High-rise			City:	Syracuse		HVAC:	Chiller and Boiler with FPFC				Measure:		RCeiling Insulation
Base	0			11			19			30			38	
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	153.8	0.289	403.0												
19	166.6	0.359	466.0	12.8	0.070	63.0									
30	172.8	0.403	503.8	18.9	0.114	100.8	6.1	0.044	37.8						
38	174.8	0.421	519.9	21.0	0.131	116.9	8.2	0.061	53.9	2.0	0.018	16.1			
49	176.5	0.447	534.9	22.6	0.158	131.9	9.8	0.088	68.9	3.7	0.044	31.1	1.7	0.026	15.0
60	177.5	0.456	543.7	23.7	0.167	140.7	10.9	0.096	77.7	4.7	0.053	39.9	2.7	0.035	23.8

Building: Multi-Family High-rise City: Syracuse HVAC: Steam Boiler Only Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	56.4												
13	0.0	0.0	73.7	0.0	0.0	17.3									
17	0.0	0.0	97.7	0.0	0.0	41.3	0.0	0.0	24.1						
19	0.0	0.0	106.5	0.0	0.0	50.1	0.0	0.0	32.8	0.0	0.0	8.7			
21	0.0	0.0	113.6	0.0	0.0	57.2	0.0	0.0	40.0	0.0	0.0	15.9	0.0	0.0	7.2
25	0.0	0.0	125.3	0.0	0.0	68.9	0.0	0.0	51.6	0.0	0.0	27.6	0.0	0.0	18.8
27	0.0	0.0	130.2	0.0	0.0	73.8	0.0	0.0	56.5	0.0	0.0	32.4	0.0	0.0	23.7

Building: Multi-Family High-rise City: Syracuse HVAC: Steam Boiler Only Measure: RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	449.0												
19	0.0	0.0	519.2	0.0	0.0	70.2									
30	0.0	0.0	561.3	0.0	0.0	112.3	0.0	0.0	42.1						
38	0.0	0.0	579.3	0.0	0.0	130.3	0.0	0.0	60.1	0.0	0.0	18.0			
49	0.0	0.0	596.0	0.0	0.0	147.0	0.0	0.0	76.8	0.0	0.0	34.7	0.0	0.0	16.7
60	0.0	0.0	605.8	0.0	0.0	156.8	0.0	0.0	86.5	0.0	0.0	44.4	0.0	0.0	26.5

Building: Multi-Family High-rise City: Binghamton HVAC: Chiller and Boiler with FPFC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	9.7	0.005	55.6												
13	12.5	0.005	72.8	2.8	0.000	17.2									
17	16.2	0.008	96.9	6.4	0.003	41.3	3.7	0.003	24.1						
19	17.5	0.008	105.5	7.7	0.003	49.9	4.9	0.003	32.7	1.3	0.000	8.6			
21	18.5	0.011	112.7	8.7	0.005	57.1	6.0	0.005	39.9	2.3	0.003	15.8	1.0	0.003	7.2
25	20.0	0.011	123.8	10.3	0.005	68.2	7.5	0.005	51.0	3.9	0.003	26.9	2.6	0.003	18.3
27	20.6	0.011	128.4	10.9	0.005	72.8	8.1	0.005	55.6	4.5	0.003	31.5	3.2	0.003	22.9

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Chiller and Boiler with FPFC **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	140.8	0.088	420.9												
19	152.9	0.096	489.0	12.1	0.009	68.1									
30	158.9	0.123	531.7	18.1	0.035	110.8	6.0	0.026	42.7						
38	161.0	0.131	548.0	20.2	0.044	127.1	8.2	0.035	59.0	2.1	0.009	16.3			
49	162.8	0.140	562.9	22.0	0.053	142.0	9.9	0.044	73.9	3.9	0.018	31.2	1.8	0.009	14.9
60	163.7	0.140	572.7	23.0	0.053	151.7	10.9	0.044	83.6	4.8	0.018	40.9	2.7	0.009	24.6

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	62.0												
13	0.0	0.0	81.1	0.0	0.0	19.2									
17	0.0	0.0	108.0	0.0	0.0	46.0	0.0	0.0	26.9						
19	0.0	0.0	117.6	0.0	0.0	55.6	0.0	0.0	36.4	0.0	0.0	9.6			
21	0.0	0.0	125.6	0.0	0.0	63.6	0.0	0.0	44.4	0.0	0.0	17.6	0.0	0.0	8.0
25	0.0	0.0	137.9	0.0	0.0	76.0	0.0	0.0	56.8	0.0	0.0	30.0	0.0	0.0	20.4
27	0.0	0.0	143.0	0.0	0.0	81.1	0.0	0.0	61.9	0.0	0.0	35.1	0.0	0.0	25.5

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Steam Boiler Only **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	469.0												
19	0.0	0.0	544.9	0.0	0.0	75.9									
30	0.0	0.0	592.5	0.0	0.0	123.5	0.0	0.0	47.6						
38	0.0	0.0	610.7	0.0	0.0	141.6	0.0	0.0	65.7	0.0	0.0	18.2			
49	0.0	0.0	627.3	0.0	0.0	158.2	0.0	0.0	82.3	0.0	0.0	34.8	0.0	0.0	16.6
60	0.0	0.0	638.1	0.0	0.0	169.1	0.0	0.0	93.2	0.0	0.0	45.6	0.0	0.0	27.4

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	12.6	0.008	40.5												
13	16.2	0.011	53.5	3.6	0.003	13.0									
17	20.9	0.014	71.9	8.3	0.005	31.4	4.7	0.003	18.4						
19	22.5	0.014	78.6	9.9	0.005	38.1	6.3	0.003	25.1	1.6	0.000	6.7			
21	23.8	0.016	83.8	11.2	0.008	43.4	7.6	0.005	30.3	2.9	0.003	11.9	1.3	0.003	5.2
25	25.7	0.016	92.0	13.1	0.008	51.5	9.5	0.005	38.5	4.8	0.003	20.1	3.2	0.003	13.4
27	26.5	0.016	95.1	13.9	0.008	54.6	10.3	0.005	41.6	5.6	0.003	23.2	4.0	0.003	16.5

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Chiller and Boiler with FPFC **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	107.4	0.105	393.0												
19	109.9	0.149	456.3	2.5	0.044	63.4									
30	109.7	0.167	495.1	2.3	0.061	102.1	-0.3	0.018	38.7						
38	109.0	0.175	512.0	1.6	0.070	119.0	-1.0	0.026	55.7	-0.7	0.009	16.9			
49	108.1	0.184	525.4	0.7	0.079	132.5	-1.8	0.035	69.1	-1.6	0.018	30.3	-0.9	0.009	13.4
60	107.3	0.193	533.8	-0.1	0.088	140.9	-2.6	0.044	77.5	-2.4	0.026	38.7	-1.7	0.018	21.8

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	45.1												
13	0.0	0.0	59.6	0.0	0.0	14.5									
17	0.0	0.0	80.1	0.0	0.0	35.0	0.0	0.0	20.5						
19	0.0	0.0	87.6	0.0	0.0	42.5	0.0	0.0	28.0	0.0	0.0	7.5			
21	0.0	0.0	93.4	0.0	0.0	48.3	0.0	0.0	33.8	0.0	0.0	13.3	0.0	0.0	5.8
25	0.0	0.0	102.5	0.0	0.0	57.4	0.0	0.0	42.9	0.0	0.0	22.4	0.0	0.0	14.9
27	0.0	0.0	105.9	0.0	0.0	60.9	0.0	0.0	46.3	0.0	0.0	25.9	0.0	0.0	18.4

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Steam Boiler Only **Measure:** RCeiling Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	437.9												
19	0.0	0.0	508.5	0.0	0.0	70.6									
30	0.0	0.0	551.7	0.0	0.0	113.8	0.0	0.0	43.2						
38	0.0	0.0	570.5	0.0	0.0	132.6	0.0	0.0	62.0	0.0	0.0	18.9			
49	0.0	0.0	585.5	0.0	0.0	147.6	0.0	0.0	77.0	0.0	0.0	33.8	0.0	0.0	14.9
60	0.0	0.0	594.8	0.0	0.0	157.0	0.0	0.0	86.3	0.0	0.0	43.2	0.0	0.0	24.3

Single-family Residential Infiltration Reduction

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
City	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm
Albany	1.8	0.006	2.2	34.0	0.002	50.8	0.006	1.1	0.000	2.2	50.1	0.000
Binghamton	1.3	0.004	2.2	35.0	0.002	49.8	0.004	1.1	0.000	2.2	49.5	0.000
Buffalo	1.6	0.004	2.4	38.8	0.005	55.6	0.004	1.3	0.000	2.4	55.2	0.000
MMassena	1.5	0.001	2.7	46.4	0.001	63.0	0.001	1.4	0.000	2.7	62.8	0.000
NYC	2.3	0.004	1.7	21.0	0.003	39.8	0.004	0.8	0.000	1.7	38.4	0.000
Poughkeepsie	1.9	0.004	1.9	24.8	0.003	43.5	0.004	1.0	0.000	1.9	42.7	0.000
Syracuse	1.8	0.003	2.4	37.3	0.003	55.1	0.003	1.2	0.000	2.4	54.6	0.000

Multi-Family Low-rise Infiltration Reduction

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
City	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm
Albany	1.5	0.004	2.4	33.5	0.004	40.0	0.004	1.4	0.000	2.4	39.9	0.000
Binghamton	1.5	0.003	2.5	32.7	0.003	40.2	0.003	1.6	0.000	2.5	40.3	0.000
Buffalo	1.0	0.003	2.3	31.2	0.002	36.6	0.003	1.1	0.000	2.3	36.7	0.000
MMassena	1.3	0.001	2.7	44.5	0.001	44.6	0.001	1.2	0.000	2.7	44.5	0.000
NYC	1.5	0.003	1.9	21.2	0.003	29.6	0.003	1.1	0.000	1.9	29.2	0.000
Poughkeepsie	1.5	0.002	2.2	24.7	0.003	29.8	0.002	1.1	0.000	2.2	29.5	0.000
Syracuse	1.6	0.004	2.5	34.1	0.004	42.2	0.004	1.6	0.000	2.5	42.2	0.000

Multi-Family High-rise Infiltration Reduction

Impact per unit of infiltration reduction (cfm)

City	kWh/cfm	kW/cfm	Therm/cfm
Albany	-1.1	0.002	7.0
Binghamton	-1.2	0.000	7.1
Buffalo	-1.1	0.002	6.5
MMassena	-0.6	0.002	8.6
NYC	0.0	0.003	5.5
Poughkeepsie	-1.2	0.005	5.6
Syracuse	-1.2	0.006	7.2

Impact per kSF square foot

City	Vintage	kWh/ 1,000 SF	kW/ 1,000SF	Therm/ 1,000SF
Albany	Old	73	0.128	30
Albany	Average	22	0.099	16
Binghamton	Old	64	0.116	33
Binghamton	Average	11	0.085	17
Buffalo	Old	68	0.101	34
Buffalo	Average	20	0.079	19
Massena	Old	66	0.127	30
Massena	Average	20	0.098	17
NYC	Old	118	0.119	29
NYC	Average	56	0.098	17
Syracuse	Old	73	0.195	29
Syracuse	Average	23	0.092	16

Baseline infiltration rate for old building is 1.0 ACH.
Baseline infiltration rate for average building is 0.5 ACH.
Energy savings based on a 15% reduction.

Commercial Ceiling Insulation Upgrade

RCeiling Insulation - Assembly

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	994	0.000	0.0
	AC with gas heat	34	0.018	43.2
	Air source heat pump	768	0.000	0.1
	Electric heat only	979	0.032	0.1
	Gas heat only	11	0.000	43.3
Binghamton	AC with electric heat	964	0.009	0.1
	AC with gas heat	30	0.038	43.3
	Air source heat pump	843	0.009	0.0
	Electric heat only	961	0.091	0.1
	Gas heat only	13	0.000	44.2
Buffalo	AC with electric heat	920	0.032	0.0
	AC with gas heat	25	0.035	41.5
	Air source heat pump	674	0.032	0.1
	Electric heat only	916	0.221	0.1
	Gas heat only	11	0.000	42.0
Massena	AC with electric heat	1,823	0.050	0.0
	AC with gas heat	54	0.053	82.1
	Air source heat pump	1,442	0.050	0.1
	Electric heat only	1,842	0.103	0.1
	Gas heat only	35	0.000	84.3
NYC	AC with electric heat	425	0.000	0.0
	AC with gas heat	37	0.026	18.4
	Air source heat pump	248	0.000	0.0
	Electric heat only	405	0.021	0.1
	Gas heat only	0	0.000	20.4
Poughkeepsie	AC with electric heat	1,005	0.047	0.1
	AC with gas heat	36	0.050	44.3
	Air source heat pump	778	0.047	0.0
	Electric heat only	991	0.012	0.1
	Gas heat only	15	0.000	44.7
Syracuse	AC with electric heat	789	0.021	0.0
	AC with gas heat	30	0.044	35.1
	Air source heat pump	789	0.021	0.1
	Electric heat only	778	0.024	0.1
	Gas heat only	6	0.000	36.1

RoofCeiling Insulation - Auto Repair

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with electric heat	564	0.000	0.2
	AC with gas heat	32	0.000	25.2
	Air source heat pump	407	0.000	0.0
	Electric heat only	524	0.019	0.0
Albany	Gas heat only	16	0.000	24.1
	AC with electric heat	489	0.039	0.2
	AC with gas heat	24	0.000	21.7
	Air source heat pump	316	0.000	0.0
	Electric heat only	441	0.039	0.2
Binghamton	Gas heat only	12	0.000	20.0
	AC with electric heat	500	0.000	0.0
	AC with gas heat	23	0.000	20.8
	Air source heat pump	315	0.000	0.0
	Electric heat only	490	0.019	0.0
Buffalo	Gas heat only	13	0.000	20.6
	AC with electric heat	585	0.000	0.0
	AC with gas heat	32	0.000	25.8
	Air source heat pump	377	0.000	0.2
	Electric heat only	564	0.000	0.0
Massena	Gas heat only	18	0.000	25.6
	AC with electric heat	915	0.000	0.0
	AC with gas heat	56	0.000	41.2
	Air source heat pump	431	0.000	0.0
	Electric heat only	882	0.000	0.0
NYC	Gas heat only	33	0.000	40.6
	AC with electric heat	754	0.019	0.2
	AC with gas heat	41	0.019	33.4
	Air source heat pump	532	0.019	0.0
	Electric heat only	748	0.019	0.2
Poughkeepsie	Gas heat only	23	0.000	33.8
	AC with electric heat	584	0.000	0.0
	AC with gas heat	34	0.000	26.4
	Air source heat pump	423	0.000	0.0
	Electric heat only	593	0.019	0.0
Syracuse	Gas heat only	18	0.000	27.6

RoofCeiling Insulation - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with electric heat	847	0.045	0.0
	AC with gas heat	-19	0.047	42.5
	Air source heat pump	682	0.045	0.0
	Electric heat only	895	0.011	0.0
Albany	Gas heat only	2	0.000	43.5
	AC with electric heat	740	0.023	0.0
	AC with gas heat	-33	0.023	38.2
	Air source heat pump	604	0.022	0.0
	Electric heat only	800	0.022	0.0
Binghamton	Gas heat only	-3	0.000	40.1
	AC with electric heat	707	0.025	0.0
	AC with gas heat	-31	0.025	36.3
	Air source heat pump	509	0.025	0.0
	Electric heat only	774	0.009	0.0
Buffalo	Gas heat only	-5	0.000	38.2
	AC with electric heat	1,213	0.043	0.0
	AC with gas heat	2	0.044	59.2
	Air source heat pump	1,072	0.043	0.0
	Electric heat only	1,263	-0.022	0.0
Massena	Gas heat only	18	0.000	60.7
	AC with electric heat	290	0.027	0.0
	AC with gas heat	-41	0.030	17.1
	Air source heat pump	141	0.027	0.0
	Electric heat only	341	0.008	0.0
NYC	Gas heat only	-32	0.000	19.0
	AC with electric heat	615	0.030	0.0
	AC with gas heat	-33	0.030	32.2
	Air source heat pump	536	0.030	0.0
	Electric heat only	680	0.014	0.0
Poughkeepsie	Gas heat only	-7	0.000	33.9
	AC with electric heat	751	0.034	0.0
	AC with gas heat	-19	0.034	38.1
	Air source heat pump	534	0.034	0.0
	Electric heat only	810	0.014	0.0
Syracuse	Gas heat only	-2	0.000	40.3

RoofCeiling Insulation - Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,009	0.000	0.5
	AC with gas heat	38	0.000	45.5
	Electric heat only	993	0.000	0.5
	Gas heat only	22	0.000	46.0
Binghamton	AC with electric heat	999	0.000	0.5
	AC with gas heat	30	0.000	45.5
	Electric heat only	1,023	0.000	0.5
	Gas heat only	24	0.000	47.0
Buffalo	AC with electric heat	1,066	0.000	0.5
	AC with gas heat	36	0.000	48.0
	Electric heat only	1,036	0.000	0.5
	Gas heat only	22	0.000	47.0
Massena	AC with electric heat	1,055	0.000	0.5
	AC with gas heat	33	0.000	47.0
	Electric heat only	1,074	0.000	0.5
	Gas heat only	26	0.000	49.5
NYC	AC with electric heat	755	0.000	0.5
	AC with gas heat	61	0.000	34.0
	Electric heat only	988	0.000	0.5
	Gas heat only	24	0.000	46.5
Poughkeepsie	AC with electric heat	994	0.050	0.0
	AC with gas heat	47	0.000	45.5
	Electric heat only	994	0.000	0.5
	Gas heat only	24	0.000	46.0
Syracuse	AC with electric heat	1,023	0.000	0.5
	AC with gas heat	43	0.050	46.5
	Electric heat only	1,097	0.000	0.5
	Gas heat only	27	0.000	50.5

RoofCeiling Insulation - Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	946	0.025	0.3
	AC with gas heat	51	0.050	42.8
	Electric heat only	941	0.000	0.3
	Gas heat only	36	0.000	43.3
Binghamton	AC with electric heat	789	0.025	0.0
	AC with gas heat	42	0.025	35.0
	Electric heat only	790	0.100	0.3
	Gas heat only	32	0.000	35.5
Buffalo	AC with electric heat	832	0.025	0.3
	AC with gas heat	43	0.025	37.8
	Electric heat only	797	0.000	0.3
	Gas heat only	31	0.000	36.8
Massena	AC with electric heat	944	0.050	0.3
	AC with gas heat	54	0.050	42.5
	Electric heat only	926	0.225	0.0
	Gas heat only	37	0.000	42.5
NYC	AC with electric heat	698	0.000	0.0
	AC with gas heat	53	0.000	32.0
	Electric heat only	688	0.000	0.0
	Gas heat only	29	0.000	32.3
Poughkeepsie	AC with electric heat	852	0.050	0.3
	AC with gas heat	57	0.025	39.5
	Electric heat only	841	0.000	0.3
	Gas heat only	40	0.000	39.8
Syracuse	AC with electric heat	915	0.025	0.3
	AC with gas heat	55	0.025	41.5
	Electric heat only	930	0.025	0.0
	Gas heat only	39	0.000	43.0

RoofCeiling Insulation – Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with electric heat	847	0.045	0.0
	AC with gas heat	-19	0.047	42.5
	Air source heat pump	682	0.045	0.0
	Electric heat only	895	0.011	0.0
Albany	Gas heat only	2	0.000	43.5
	AC with electric heat	740	0.023	0.0
	AC with gas heat	-33	0.023	38.2
	Air source heat pump	604	0.022	0.0
	Electric heat only	800	0.022	0.0
Binghamton	Gas heat only	-3	0.000	40.1
	AC with electric heat	707	0.025	0.0
	AC with gas heat	-31	0.025	36.3
	Air source heat pump	509	0.025	0.0
	Electric heat only	774	0.009	0.0
Buffalo	Gas heat only	-5	0.000	38.2
	AC with electric heat	1,213	0.043	0.0
	AC with gas heat	2	0.044	59.2
	Air source heat pump	1,072	0.043	0.0
	Electric heat only	1,263	-0.022	0.0
Massena	Gas heat only	18	0.000	60.7
	AC with electric heat	290	0.027	0.0
	AC with gas heat	-41	0.030	17.1
	Air source heat pump	141	0.027	0.0
	Electric heat only	341	0.008	0.0
NYC	Gas heat only	-32	0.000	19.0
	AC with electric heat	615	0.030	0.0
	AC with gas heat	-33	0.030	32.2
	Air source heat pump	536	0.030	0.0
	Electric heat only	680	0.014	0.0
Poughkeepsie	Gas heat only	-7	0.000	33.9
	AC with electric heat	751	0.034	0.0
	AC with gas heat	-19	0.034	38.1
	Air source heat pump	534	0.034	0.0
	Electric heat only	810	0.014	0.0
Syracuse	Gas heat only	-2	0.000	40.3

RoofCeiling Insulation – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	929.2	0.023	0.0
	AC with gas heat	44.6	0.024	44.1
	Air source heat pump	585.4	0.023	0.0
	Electric heat only	937.3	0.000	0.0
	Gas heat only	51.2	0.000	44.1
Binghamton	AC with electric heat	968.31	0.015	0
	AC with gas heat	46.13	0.016	45.89
	Air source heat pump	601.99	0.016	0.01
	Electric heat only	976.42	0	0.01
	Gas heat only	54.68	0	45.86
Buffalo	AC with electric heat	929.55	0.017	0
Buffalo	AC with gas heat	43.78	0.017	44.23
	Air source heat pump	570.1	0.018	0.01
	Electric heat only	939.85	0	0.02
	Gas heat only	54.07	0	44.2
Massena	AC with electric heat	1,079.08	0.025	0.01
	AC with gas heat	48	0.026	50.82
	Air source heat pump	724.88	0.025	0
	Electric heat only	1,087.71	0	0.01
	Gas heat only	54.87	0	50.86
NYC	AC with electric heat	654.92	0.011	0.01
	AC with gas heat	54.62	0.012	30.9
	Air source heat pump	344.94	0.01	0.01
	Electric heat only	647.28	0	0.01
	Gas heat only	49.87	0	30.63
Poughkeepsie	AC with electric heat	828.65	0.016	0
	AC with gas heat	48.18	0.016	39.47
	Air source heat pump	504.04	0.016	0.01
	Electric heat only	833.7	0	0.02
	Gas heat only	53.81	0	39.46
Syracuse	AC with electric heat	922.95	0.018	0
	AC with gas heat	49.54	0.018	43.6
	Air source heat pump	579.35	0.018	0
	Electric heat only	926.66	0	0.01
	Gas heat only	54.2	0	43.54

RoofCeiling Insulation – Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	-4.3	0.073	12.9
	AC with electric heat	264.3	0.073	0.0
	Air source heat pump	235.0	0.073	0.0
	Electric heat only	272.9	0.000	0.0
	Gas heat only	0.3	0.000	13.1
Binghamton	AC with gas heat	-8.9	-0.013	13.6
	AC with electric heat	276.1	-0.013	0.0
	Air source heat pump	245.4	-0.013	0.0
	Electric heat only	289.3	0.033	0.0
	Gas heat only	1.1	0.000	13.9
Buffalo	AC with gas heat	-10.7	-0.007	13.2
	AC with electric heat	264.8	-0.007	0.0
	Air source heat pump	235.2	-0.007	0.0
	Electric heat only	277.7	0.000	0.0
	Gas heat only	0.5	0.000	13.2
Massena	AC with gas heat	-5.9	0.067	15.3
	AC with electric heat	314.8	0.067	0.0
	Air source heat pump	292.9	0.067	0.0
	Electric heat only	322.8	0.000	0.0
	Gas heat only	0.5	0.000	15.3
NYC	AC with gas heat	-1.8	0.027	8.6
	AC with electric heat	175.6	0.027	0.0
	Air source heat pump	139.9	0.027	0.0
	Electric heat only	182.6	0.000	0.0
	Gas heat only	0.1	0.000	8.8
Poughkeepsie	AC with gas heat	-4.8	-0.033	10.9
	AC with electric heat	220.8	-0.033	0.0
	Air source heat pump	188.2	-0.033	0.0
	Electric heat only	230.2	0.000	0.0
	Gas heat only	0.5	0.000	11.1
Syracuse	AC with gas heat	-0.4	0.060	12.7
	AC with electric heat	267.5	0.060	0.0
	Air source heat pump	242.0	0.060	0.0
	Electric heat only	270.5	0.000	0.0
	Gas heat only	0.3	0.000	12.9

RoofCeiling Insulation - Elementary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,456	0.130	0.1
	AC with gas heat	121	0.134	59.9
	Air source heat pump	916	0.130	0.1
	Electric heat only	1,411	0.006	0.1
	Gas heat only	86	0.000	59.8
Binghamton	AC with electric heat	1,369	0.030	0.0
	AC with gas heat	110	0.030	56.6
	Air source heat pump	813	0.030	0.0
	Electric heat only	1,337	0.006	0.1
	Gas heat only	85	0.000	56.4
Buffalo	AC with electric heat	1,366	0.360	0.0
	AC with gas heat	107	0.360	56.7
	Air source heat pump	831	0.360	0.0
	Electric heat only	1,345	0.012	0.1
	Gas heat only	85	0.044	56.8
Massena	AC with electric heat	1,560	0.134	0.0
	AC with gas heat	121	0.052	64.1
	Air source heat pump	1030	0.134	0.0
	Electric heat only	1519	-0.002	0.1
	Gas heat only	83	0.000	64.0
NYC	AC with electric heat	1072	0.206	0.0
	AC with gas heat	146	0.204	43.1
	Air source heat pump	550	0.208	0.0
	Electric heat only	1,000	0.046	0.1
	Gas heat only	86	0.098	42.5
Poughkeepsie	AC with electric heat	1371	0.352	0.0
	AC with gas heat	142	0.352	56.1
	Air source heat pump	842	0.350	0.0
	Electric heat only	1332	0.000	0.1
	Gas heat only	95	0.000	56.5
Syracuse	AC with electric heat	1326	0.056	0.1
	AC with gas heat	123	0.054	54.3
	Air source heat pump	799	0.056	0.1
	Electric heat only	1267	-0.014	0.1
	Gas heat only	79	0.000	53.6

RoofCeiling Insulation – Religious Worship

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	994	0.000	0.0
	AC with gas heat	34	0.018	43.2
	Air source heat pump	768	0.000	0.1
	Electric heat only	979	0.032	0.1
	Gas heat only	11	0.000	43.3
Binghamton	AC with electric heat	964	0.009	0.1
	AC with gas heat	30	0.038	43.3
	Air source heat pump	843	0.009	0.0
	Electric heat only	961	0.091	0.1
	Gas heat only	13	0.000	44.2
Buffalo	AC with electric heat	920	0.032	0.0
	AC with gas heat	25	0.035	41.5
	Air source heat pump	674	0.032	0.1
	Electric heat only	916	0.221	0.1
	Gas heat only	11	0.000	42.0
Massena	AC with electric heat	1,823	0.050	0.0
	AC with gas heat	54	0.053	82.1
	Air source heat pump	1,442	0.050	0.1
	Electric heat only	1,842	0.103	0.1
	Gas heat only	35	0.000	84.3
NYC	AC with electric heat	425	0.000	0.0
	AC with gas heat	37	0.026	18.4
	Air source heat pump	248	0.000	0.0
	Electric heat only	405	0.021	0.1
	Gas heat only	-5	0.000	20.4
Poughkeepsie	AC with electric heat	1,005	0.047	0.1
	AC with gas heat	36	0.050	44.3
	Air source heat pump	778	0.047	0.0
	Electric heat only	991	0.012	0.1
	Gas heat only	15	0.000	44.7
Syracuse	AC with electric heat	789	0.021	0.0
	AC with gas heat	30	0.044	35.1
	Air source heat pump	789	0.021	0.1
	Electric heat only	778	0.024	0.1
	Gas heat only	6	0.000	36.1

RoofCeiling Insulation – Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	649	0.04	0
	AC with gas heat	28.2	0.04	31
	Air source heat pump	412	0.04	0
	Electric heat only	631.4	0	0
	Gas heat only	13.6	0	30.4
Binghamton	AC with electric heat	670.2	0.02	0
	AC with gas heat	24.8	0.02	32
	Air source heat pump	415.6	0.02	0
	Electric heat only	651.8	0	0.2
	Gas heat only	17.2	0	31.2
Buffalo	AC with electric heat	652.4	0	0
	AC with gas heat	24.8	0.02	31.2
	Air source heat pump	402.2	0.02	0
	Electric heat only	644.4	0	0
	Gas heat only	17.4	0	31
Massena	AC with electric heat	787.8	0.04	0
	AC with gas heat	33.6	0.02	36.8
	Air source heat pump	551.4	0.02	0
	Electric heat only	776.8	0	0
	Gas heat only	18.4	0	37.2
NYC	AC with electric heat	429.6	0.04	0
	AC with gas heat	36.8	0.04	20
	Air source heat pump	226.6	0.04	0
	Electric heat only	384.2	0	0
	Gas heat only	-1.6	0	19.6
Poughkeepsie	AC with electric heat	554.8	0.02	0
	AC with gas heat	31	0.02	26.4
	Air source heat pump	346.6	0.02	0
	Electric heat only	539.4	0	0
	Gas heat only	14.4	0	26.2
Syracuse	AC with electric heat	640.4	0.02	0
	AC with gas heat	33.2	0.04	30.2
	Air source heat pump	401.4	0.04	0
	Electric heat only	622.8	0	0
	Gas heat only	16.2	0	30

RoofCeiling Insulation – Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,013	0.063	0.2
	AC with gas heat	60	0.063	47.2
	Air source heat pump	671	0.063	0.2
	Electric heat only	977	0.000	0.2
	Gas heat only	38	0.000	46.4
Binghamton	AC with electric heat	1,005	0.031	0.2
	AC with gas heat	50	0.031	47.3
	Air source heat pump	659	0.047	0.2
	Electric heat only	987	0.016	0.2
	Gas heat only	40	0.000	46.9
Buffalo	AC with electric heat	998	0.031	0.2
	AC with gas heat	53	0.031	46.9
	Air source heat pump	602	0.047	0.2
	Electric heat only	982	0.000	0.2
	Gas heat only	42	0.000	46.9
Massena	AC with electric heat	1,174	0.063	0.2
	AC with gas heat	63	0.063	54.5
	Air source heat pump	792	0.047	0.0
	Electric heat only	1,152	0.000	0.2
	Gas heat only	45	0.000	54.1
NYC	AC with electric heat	678	0.016	0.2
	AC with gas heat	66	0.031	31.6
	Air source heat pump	362	0.031	0.2
	Electric heat only	625	0.000	0.2
	Gas heat only	24	0.000	30.6
Poughkeepsie	AC with electric heat	836	0.063	0.0
	AC with gas heat	54	0.047	39.4
	Air source heat pump	511	0.047	0.0
	Electric heat only	800	0.000	0.2
	Gas heat only	32	0.000	38.4
Syracuse	AC with electric heat	1,026	0.047	0.0
	AC with gas heat	65	0.047	48.0
	Air source heat pump	660	0.047	0.0
	Electric heat only	1,006	0.000	0.2
	Gas heat only	46	0.000	47.8

RoofCeiling Insulation – Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,631	0.001	0.0
	AC with gas heat	13	0.001	65.6
	Air source heat pump	1,215	0.001	0.0
	Electric heat only	1,614	0.000	0.0
	Gas heat only	0	0.000	65.3
Binghamton	AC with electric heat	1,656	0.037	0.0
	AC with gas heat	5	0.058	66.7
	Air source heat pump	1,228	0.037	0.0
	Electric heat only	1,650	0.000	0.0
	Gas heat only	0	0.000	66.7
Buffalo	AC with electric heat	1,584	0.069	0.0
	AC with gas heat	0	0.084	64.2
	Air source heat pump	1,141	0.069	0.0
	Electric heat only	1,585	0.000	0.0
	Gas heat only	0	0.000	64.2
Massena	AC with electric heat	1,522	0.001	0.0
	AC with gas heat	22	0.000	60.4
	Air source heat pump	1,083	0.002	0.0
	Electric heat only	1,501	0.000	0.0
	Gas heat only	0	0.000	60.5
NYC	AC with electric heat	1,468	0.076	0.0
	AC with gas heat	48	0.121	60.3
	Air source heat pump	925	0.076	0.0
	Electric heat only	1,416	0.000	0.0
	Gas heat only	0	0.000	60.1
Poughkeepsie	AC with electric heat	1,612	0.129	0.0
	AC with gas heat	26	0.132	65.8
	Air source heat pump	1,004	0.129	0.0
	Electric heat only	1,586	0.000	0.0
	Gas heat only	0	0.000	65.8
Syracuse	AC with electric heat	1,817	0.039	0.0
	AC with gas heat	21	0.074	72.4
	Air source heat pump	1,409	0.040	0.0
	Electric heat only	1,796	0.000	0.0
	Gas heat only	0	0.000	72.5

RoofCeiling Insulation – Community College

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV reheat no econ with Air Cooled Chiller	-33	-0.001	4.5
	CV reheat no econ with Water Cooled Chiller	-30	0.000	4.5
	CV reheat econ with Air Cooled Chiller	0	-0.001	4.0
	CV reheat econ with Water Cooled Chiller	-5	0.000	4.0
	VAV reheat econ with Air Cooled Chiller	-6	0.042	2.1
	VAV reheat econ with Water Cooled Chiller	-8	0.043	2.1
Binghamton	CV reheat no econ with Air Cooled Chiller	-32	0.001	3.3
	CV reheat no econ with Water Cooled Chiller	-30	0.001	3.3
	CV reheat econ with Air Cooled Chiller	-2	0.001	3.3
	CV reheat econ with Water Cooled Chiller	-6	0.001	3.2
	VAV reheat econ with Air Cooled Chiller	-3	0.031	2.4
	VAV reheat econ with Water Cooled Chiller	-5	0.026	2.4
Buffalo	CV reheat no econ with Air Cooled Chiller	-32	0.001	4.1
	CV reheat no econ with Water Cooled Chiller	-33	0.011	4.1
	CV reheat econ with Air Cooled Chiller	-1	0.001	3.7
	CV reheat econ with Water Cooled Chiller	-5	0.011	3.7
	VAV reheat econ with Air Cooled Chiller	9	0.034	4.5
	VAV reheat econ with Water Cooled Chiller	8	0.026	4.5

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Massena	CV reheat no econ with Air Cooled Chiller	-36	0.001	4.6
	CV reheat no econ with Water Cooled Chiller	-34	0.001	4.6
	CV reheat econ with Air Cooled Chiller	-1	0.001	4.0
	CV reheat econ with Water Cooled Chiller	-6	0.001	4.0
	VAV reheat econ with Air Cooled Chiller	-1	0.067	2.4
	VAV reheat econ with Water Cooled Chiller	-2	0.046	2.4
NYC	CV reheat no econ with Air Cooled Chiller	-39	0.001	5.8
	CV reheat no econ with Water Cooled Chiller	-30	0.000	5.9
	CV reheat econ with Air Cooled Chiller	12	0.001	4.1
	CV reheat econ with Water Cooled Chiller	2	0.000	4.1
	VAV reheat econ with Air Cooled Chiller	24	0.049	4.7
	VAV reheat econ with Water Cooled Chiller	20	0.032	4.7
Poughkeepsie	CV reheat no econ with Air Cooled Chiller	-42	0.000	6.4
	CV reheat no econ with Water Cooled Chiller	-27	0.001	6.5
	CV reheat econ with Air Cooled Chiller	5	0.000	4.8
	CV reheat econ with Water Cooled Chiller	1	0.001	4.8
	VAV reheat econ with Air Cooled Chiller	22	0.008	9.5
	VAV reheat econ with Water Cooled Chiller	17	0.018	9.5

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Syracuse	CV reheat no econ with Air Cooled Chiller	-33	0.000	4.8
	CV reheat no econ with Water Cooled Chiller	-32	0.001	4.8
	CV reheat econ with Air Cooled Chiller	2	0.000	3.9
	CV reheat econ with Water Cooled Chiller	-3	0.001	3.9
	VAV reheat econ with Air Cooled Chiller	7	0.043	3.6
	VAV reheat econ with Water Cooled Chiller	5	0.030	3.6

RoofCeiling Insulation – University

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-18	0.003	5.6
	CV Econ Air Cooled	-3	0.003	3.3
	CV Econ Water Cooled	-1	0.003	3.3
	VAV Econ Air Cooled	5	0.003	3.0
	VAV Econ Water Cooled	8	0.003	2.8
Binghamton	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-24	0.002	5.9
	CV Econ Air Cooled	-3	0.001	3.6
	CV Econ Water Cooled	-1	0.002	3.7
	VAV Econ Air Cooled	0	0.002	1.9
	VAV Econ Water Cooled	6	0.003	2.7
Buffalo	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-18	0.002	5.9
	CV Econ Air Cooled	-2	0.002	3.6
	CV Econ Water Cooled	-1	0.001	3.1
	VAV Econ Air Cooled	-19	0.002	-2.1
	VAV Econ Water Cooled	-20	0.002	-1.9
Massena	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-24	0.001	5.2
	CV Econ Air Cooled	-1	0.002	3.2
	CV Econ Water Cooled	0	0.001	3.2
	VAV Econ Air Cooled	33	0.002	7.7
	VAV Econ Water Cooled	33	0.001	7.7
NYC	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-15	0.002	4.6
	CV Econ Air Cooled	-1	0.003	2.8
	CV Econ Water Cooled	0	0.002	2.8
	VAV Econ Air Cooled	11	0.003	4.0
	VAV Econ Water Cooled	10	0.002	3.9
Poughkeepsie	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-16	0.002	5.0
	CV Econ Air Cooled	-2	0.001	2.9
	CV Econ Water Cooled	-1	0.002	2.8
	VAV Econ Air Cooled	3	0.001	3.2
	VAV Econ Water Cooled	4	0.001	3.3
Syracuse	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-20	0.002	5.0
	CV Econ Air Cooled	-3	0.002	3.0
	CV Econ Water Cooled	-1	0.002	3.0
	VAV Econ Air Cooled	13	0.002	3.0
	VAV Econ Water Cooled	20	0.057	4.5

RoofCeiling Insulation – High School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-15	0.000	7.7
	CV No Econ Water Cooled	-12	0.000	7.8
	CV Econ Air Cooled	-11	0.000	7.5
	CV Econ Water Cooled	-8	0.000	7.5
	VAV Econ Air Cooled	-11	0.000	7.5
	VAV Econ Water Cooled	-8	0.000	7.5
Binghamton	CV No Econ Air Cooled	-16	0.000	7.2
	CV No Econ Water Cooled	-12	0.000	7.2
	CV Econ Air Cooled	-12	0.000	7.0
	CV Econ Water Cooled	-8	0.000	7.0
	VAV Econ Air Cooled	-12	0.000	7.0
	VAV Econ Water Cooled	-8	0.000	7.0
Buffalo	CV No Econ Air Cooled	-17	0.000	6.1
	CV No Econ Water Cooled	-12	0.000	6.1
	CV Econ Air Cooled	-16	0.000	5.1
	CV Econ Water Cooled	-9	0.000	6.1
	VAV Econ Air Cooled	-16	0.000	5.1
	VAV Econ Water Cooled	-9	0.000	6.1
Massena	CV No Econ Air Cooled	-16	0.000	7.8
	CV No Econ Water Cooled	-13	0.000	7.8
	CV Econ Air Cooled	-12	0.000	7.7
	CV Econ Water Cooled	-9	0.000	7.7
	VAV Econ Air Cooled	-12	0.000	7.7
	VAV Econ Water Cooled	-9	0.000	7.7
NYC	CV No Econ Air Cooled	-14	0.000	4.1
	CV No Econ Water Cooled	-10	0.000	4.1
	CV Econ Air Cooled	-10	0.000	4.2
	CV Econ Water Cooled	-6	0.000	4.2
	VAV Econ Air Cooled	-10	0.000	4.2
	VAV Econ Water Cooled	-6	0.000	4.2
Poughkeepsie	CV No Econ Air Cooled	-18	0.000	4.3
	CV No Econ Water Cooled	-13	0.000	4.3
	CV Econ Air Cooled	-11	0.000	5.3
	CV Econ Water Cooled	-8	0.000	5.3
	VAV Econ Air Cooled	-11	0.000	5.3
	VAV Econ Water Cooled	-8	0.000	5.3
Syracuse	CV No Econ Air Cooled	-11	0.000	8.1
	CV No Econ Water Cooled	-10	0.000	6.7
	CV Econ Air Cooled	-10	0.000	6.7
	CV Econ Water Cooled	-7	0.000	6.7
	VAV Econ Air Cooled	-10	0.000	6.7
	VAV Econ Water Cooled	-7	0.000	6.7

RoofCeiling Insulation – Large Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-4	0.013	12.0
	CV No Econ Water Cooled	-2	0.008	12.0
	CV Econ Air Cooled	0	0.013	12.1
	CV Econ Water Cooled	1	0.008	12.1
	VAV Econ Air Cooled	-8	0.010	7.9
	VAV Econ Water Cooled	-9	0.007	7.9
Binghamton	CV No Econ Air Cooled	-8	0.005	11.7
	CV No Econ Water Cooled	-5	0.003	11.7
	CV Econ Air Cooled	-2	0.003	11.7
	CV Econ Water Cooled	-1	0.003	11.7
	VAV Econ Air Cooled	-11	0.005	8.1
	VAV Econ Water Cooled	-13	0.003	8.1
Buffalo	CV No Econ Air Cooled	-5	0.003	11.7
	CV No Econ Water Cooled	-4	0.000	11.7
	CV Econ Air Cooled	-1	0.000	11.8
	CV Econ Water Cooled	-1	0.003	11.8
	VAV Econ Air Cooled	-11	0.003	8.6
	VAV Econ Water Cooled	-11	0.000	8.6
Massena	CV No Econ Air Cooled	-3	0.010	13.6
	CV No Econ Water Cooled	-5	0.003	13.6
	CV Econ Air Cooled	0	0.010	13.4
	CV Econ Water Cooled	-1	0.002	13.4
	VAV Econ Air Cooled	-4	0.013	9.9
	VAV Econ Water Cooled	-5	0.003	9.9
NYC	CV No Econ Air Cooled	-5	0.000	7.5
	CV No Econ Water Cooled	-3	0.000	7.5
	CV Econ Air Cooled	1	0.000	7.4
	CV Econ Water Cooled	-1	0.000	7.4
	VAV Econ Air Cooled	-12	0.008	5.9
	VAV Econ Water Cooled	-11	0.005	5.9
Poughkeepsie	CV No Econ Air Cooled	-3	0.005	10.2
	CV No Econ Water Cooled	-4	0.003	10.2
	CV Econ Air Cooled	0	0.005	10.3
	CV Econ Water Cooled	1	0.003	10.3
	VAV Econ Air Cooled	-13	0.005	5.7
	VAV Econ Water Cooled	-12	0.003	5.7
Syracuse	CV No Econ Air Cooled	-4	0.007	11.6
	CV No Econ Water Cooled	-3	0.005	11.6
	CV Econ Air Cooled	1	0.007	11.6
	CV Econ Water Cooled	0	0.005	11.6
	VAV Econ Air Cooled	-9	0.010	8.1
	VAV Econ Water Cooled	-7	0.003	8.1

RoofCeiling Insulation – Hospital

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-51	0.034	9.2
	CV No Econ Water Cooled	-40	0.023	9.2
	CV Econ Air Cooled	11	0.034	7.4
	CV Econ Water Cooled	7	0.023	7.4
	VAV Econ Air Cooled	12	0.044	25.6
	VAV Econ Water Cooled	12	0.028	25.6
Binghamton	CV No Econ Air Cooled	-61	0.017	8.9
	CV No Econ Water Cooled	-56	0.010	8.9
	CV Econ Air Cooled	8	0.017	7.3
	CV Econ Water Cooled	7	0.008	7.4
	VAV Econ Air Cooled	-4	0.023	20.8
	VAV Econ Water Cooled	-4	0.010	20.8
Buffalo	CV No Econ Air Cooled	-58	0.012	9.0
	CV No Econ Water Cooled	-45	0.007	9.0
	CV Econ Air Cooled	4	0.012	7.4
	CV Econ Water Cooled	5	0.007	7.4
	VAV Econ Air Cooled	0	0.017	19.2
	VAV Econ Water Cooled	2	0.011	19.2
Massena	CV No Econ Air Cooled	-59	0.035	11.5
	CV No Econ Water Cooled	-39	0.018	11.5
	CV Econ Air Cooled	10	0.035	9.4
	CV Econ Water Cooled	10	0.017	9.4
	VAV Econ Air Cooled	8	0.043	23.9
	VAV Econ Water Cooled	7	0.019	22.1
NYC	CV No Econ Air Cooled	-40	0.040	5.2
	CV No Econ Water Cooled	-25	0.018	5.2
	CV Econ Air Cooled	19	0.040	4.2
	CV Econ Water Cooled	17	0.018	4.2
	VAV Econ Air Cooled	4	0.047	12.5
	VAV Econ Water Cooled	3	0.019	12.5
Poughkeepsie	CV No Econ Air Cooled	-47	0.016	7.4
	CV No Econ Water Cooled	-35	0.004	7.4
	CV Econ Air Cooled	15	0.016	6.4
	CV Econ Water Cooled	11	0.004	6.4
	VAV Econ Air Cooled	1	-0.065	12.2
	VAV Econ Water Cooled	4	0.014	12.2
Syracuse	CV No Econ Air Cooled	-60	0.030	8.7
	CV No Econ Water Cooled	-46	0.018	8.7
	CV Econ Air Cooled	13	0.029	6.8
	CV Econ Water Cooled	9	0.019	6.8
	VAV Econ Air Cooled	10	0.037	22.3
	VAV Econ Water Cooled	5	0.023	22.3

RoofCeiling Insulation – Hotel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-220	0.042	4.0
	CV No Econ Water Cooled	-221	0.036	4.0
	CV Econ Air Cooled	-207	0.042	4.1
	CV Econ Water Cooled	-207	0.036	4.1
	VAV Econ Air Cooled	-215	0.036	4.5
	VAV Econ Water Cooled	-215	0.036	4.5
Binghamton	CV No Econ Air Cooled	-380	0.031	4.2
	CV No Econ Water Cooled	-382	0.031	4.3
	CV Econ Air Cooled	-362	0.031	4.3
	CV Econ Water Cooled	-362	0.031	4.3
	VAV Econ Air Cooled	-370	0.031	4.5
	VAV Econ Water Cooled	-370	0.031	4.5
Buffalo	CV No Econ Air Cooled	-334	0.031	3.8
	CV No Econ Water Cooled	-335	0.036	3.8
	CV Econ Air Cooled	-350	0.031	4.0
	CV Econ Water Cooled	-350	0.036	4.0
	VAV Econ Air Cooled	-359	0.031	4.3
	VAV Econ Water Cooled	-358	0.036	4.3
Massena	CV No Econ Air Cooled	-127	0.057	5.1
	CV No Econ Water Cooled	-132	0.057	5.1
	CV Econ Air Cooled	-105	0.057	5.3
	CV Econ Water Cooled	-105	0.057	5.3
	VAV Econ Air Cooled	-111	0.057	6.1
	VAV Econ Water Cooled	-111	0.057	6.1
NYC	CV No Econ Air Cooled	-215	0.062	2.7
	CV No Econ Water Cooled	-215	0.062	2.7
	CV Econ Air Cooled	-201	0.062	2.8
	CV Econ Water Cooled	-202	0.062	2.8
	VAV Econ Air Cooled	-207	0.062	2.0
	VAV Econ Water Cooled	-207	0.062	2.0
Poughkeepsie	CV No Econ Air Cooled	-397	0.042	3.7
	CV No Econ Water Cooled	-400	0.042	3.7
	CV Econ Air Cooled	-379	0.042	3.8
	CV Econ Water Cooled	-379	0.042	3.8
	VAV Econ Air Cooled	-385	0.036	3.5
	VAV Econ Water Cooled	-385	0.036	3.5
Syracuse	CV No Econ Air Cooled	-147	0.047	4.0
	CV No Econ Water Cooled	-149	0.047	4.0
	CV Econ Air Cooled	-131	0.047	4.1
	CV Econ Water Cooled	-131	0.047	4.1
	VAV Econ Air Cooled	-138	0.047	4.4
	VAV Econ Water Cooled	-138	0.052	4.4

RoofCeiling Insulation – Large Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Water Cooled	155	0.034	45.7
	CV Econ Air Cooled	260	0.040	52.8
	CV Econ Water Cooled	256	0.000	52.5
	VAV Econ Air Cooled	140	0.057	45.1
	VAV Econ Water Cooled	148	0.017	45.1
Buffalo	CV No Econ Air Cooled	106	0.023	35.1
	CV No Econ Water Cooled	75	0.017	35.2
	CV Econ Air Cooled	146	0.000	34.0
	CV Econ Water Cooled	131	0.000	34.1
	VAV Econ Air Cooled	83	0.000	37.3
	VAV Econ Water Cooled	85	0.000	37.3
Binghamton	CV No Econ Air Cooled	198	0.023	42.6
	CV No Econ Water Cooled	194	0.011	42.6
	CV Econ Air Cooled	128	0.029	32.3
	CV Econ Water Cooled	127	0.000	32.4
	VAV Econ Air Cooled	90	0.000	37.4
	VAV Econ Water Cooled	95	0.006	37.4
Massena	CV No Econ Air Cooled	148	0.040	42.3
	CV No Econ Water Cooled	113	0.029	42.4
	CV Econ Air Cooled	153	0.000	34.6
	CV Econ Water Cooled	143	0.000	34.5
	VAV Econ Air Cooled	206	0.000	54.4
	VAV Econ Water Cooled	205	0.000	54.4
NYC	CV No Econ Air Cooled	153	0.046	34.3
	CV No Econ Water Cooled	45	0.023	34.2
	CV Econ Air Cooled	194	0.046	45.2
	CV Econ Water Cooled	178	0.000	45.2
	VAV Econ Air Cooled	23	0.000	10.7
	VAV Econ Water Cooled	39	0.006	10.7
Poughkeepsie	CV No Econ Air Cooled	31	0.051	25.0
	CV No Econ Water Cooled	121	0.006	24.9
	CV Econ Air Cooled	161	0.000	35.7
	CV Econ Water Cooled	153	0.000	35.6
	VAV Econ Air Cooled	125	0.006	32.6
	VAV Econ Water Cooled	124	0.006	32.6
Syracuse	CV No Econ Air Cooled	326	0.046	52.5
	CV No Econ Water Cooled	234	0.023	52.6
	CV Econ Air Cooled	311	0.040	59.5
	CV Econ Water Cooled	298	0.000	59.1
	VAV Econ Air Cooled	134	0.051	44.9
	VAV Econ Water Cooled	147	0.029	45.0

RCeiling Insulation – Dormitory

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	Fan coil with Air Cooled Chiller	70.3	0.064	11.8
	Fan coil with Water Cooled Chiller	91.4	0.058	11.8
	Heat only	16.1	0.004	11.2
Binghamton	Fan coil with Air Cooled Chiller	56.3	0.042	12.4
	Fan coil with Water Cooled Chiller	71.8	0.054	12.4
	Heat only	15.2	0.004	11.9
Buffalo	Fan coil with Air Cooled Chiller	62.2	0.044	12.5
	Fan coil with Water Cooled Chiller	79.1	0.052	12.5
	Heat only	15.4	0.004	12.2
Massena	Fan coil with Air Cooled Chiller	68.2	0.054	14.4
	Fan coil with Water Cooled Chiller	90.7	0.262	14.4
	Heat only	16.5	0.006	14.0
NYC	Fan coil with Air Cooled Chiller	13.0	0.036	10.4
	Fan coil with Water Cooled Chiller	15.3	-0.028	10.4
	Heat only	3.7	0.000	10.3
Poughkeepsie	Fan coil with Air Cooled Chiller	69.7	0.044	10.5
	Fan coil with Water Cooled Chiller	93.7	0.062	10.5
	Heat only	17.1	0.004	10.1
Syracuse	Fan coil with Air Cooled Chiller	72.8	0.060	12.1
	Fan coil with Water Cooled Chiller	94.9	0.066	12.1
	Heat only	16.5	0.004	11.5

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-24	7/31/2013
7-13-25	7/31/2013
7-13-26	7/31/2013

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APPENDIX F

WINDOW AND HIGH PERFORMANCE GLAZING

SINGLE-FAMILY RESIDENTIAL ENERGY STAR® WINDOWS

Albany

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	96.4	0.127	17.0	386.8	0.124	481.6	0.127	7.7	0.000	16.9	393.0	0.000
2 pane	47.7	0.067	5.2	147.3	0.074	167.5	0.067	2.1	0.000	5.2	122.0	0.000
Code	1.3	0.003	3.7	49.3	0.003	81.1	0.003	1.8	0.000	3.7	81.5	0.000

Binghamton

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	75.7	0.104	19.3	420.4	0.107	517.5	0.104	9.3	0.000	19.2	451.1	0.000
2 pane	36.2	0.054	6.1	156.3	0.054	177.3	0.054	2.6	0.000	6.0	143.8	0.000
Code	1.6	0.003	3.9	56.8	0.003	88.2	0.003	2.1	0.000	3.9	88.6	0.000

Buffalo

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	86.5	0.107	20.4	440.2	0.104	553.0	0.107	9.8	0.000	20.4	476.3	0.000
2 pane	43.7	0.060	7.2	176.4	0.057	210.2	0.060	3.4	0.000	7.2	169.9	0.000
Code	1.7	0.003	3.8	54.0	0.003	85.0	0.003	1.9	0.000	3.8	85.1	0.000

Massena

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	84.4	0.111	21.0	490.9	0.117	566.9	0.111	9.6	0.000	20.9	492.0	0.000
2 pane	40.9	0.057	6.5	183.2	0.064	194.4	0.057	2.7	0.000	6.5	156.1	0.000
Code	2.0	0.000	4.4	68.2	0.000	98.5	0.000	2.2	0.000	4.4	98.6	0.000

NYC

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	125.5	0.117	9.2	252.7	0.124	336.0	0.117	4.0	0.000	9.1	214.6	0.000
2 pane	64.5	0.060	1.6	98.7	0.060	106.3	0.060	0.5	0.000	1.5	42.4	0.000
Code	1.1	0.003	2.7	27.4	0.003	59.9	0.003	1.3	0.000	2.7	60.2	0.000

Poughkeepsie

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	86.6	0.104	11.9	277.1	0.117	359.1	0.104	5.5	0.000	11.8	277.8	0.000
2 pane	44.0	0.054	3.2	109.2	0.060	121.1	0.054	1.3	0.000	3.1	78.4	0.000
Code	1.4	0.000	3.4	38.8	0.000	72.3	0.000	1.6	0.000	3.4	72.6	0.000

Syracuse

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	94.5	0.091	18.4	396.4	0.101	510.4	0.091	8.7	0.000	18.3	424.6	0.000
2 pane	47.6	0.064	6.0	153.9	0.067	185.3	0.064	2.6	0.000	5.9	140.4	0.000
Code	1.1	0.003	3.7	48.6	0.000	81.0	0.003	1.8	0.000	3.7	81.8	0.000

MULTI-FAMILY LOW-RISE ENERGY STAR® WINDOWS

Albany

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	148.4	0.228	87.9	1,269.5	0.221	1,668.6	0.228	69.3	0.057	87.9	1,589.5	0.057
2 pane	72.1	0.117	36.3	531.0	0.114	716.9	0.117	31.5	0.057	36.3	676.2	0.057
Code	6.4	0.003	11.3	134.3	0.007	173.4	0.003	6.7	0.003	11.3	173.5	0.003

Binghamton

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	122.3	0.174	99.3	1,426.3	0.168	1,832.4	0.174	61.0	0.007	99.3	1,771.0	0.007
2 pane	57.3	0.091	42.1	605.1	0.087	793.6	0.091	26.0	0.003	42.1	762.2	0.003
Code	6.8	0.003	12.1	137.8	0.003	177.9	0.003	7.3	0.003	12.1	178.3	0.003

Buffalo

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	121.1	0.164	90.8	1,315.5	0.158	1,688.8	0.164	55.1	0.030	90.8	1,622.9	0.030
2 pane	56.3	0.084	37.3	543.2	0.084	701.6	0.084	21.9	0.007	37.3	667.2	0.007
Code	5.6	0.003	12.0	134.9	0.003	173.7	0.003	6.2	0.000	12.0	174.4	0.000

Massena

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	132.4	0.171	100.4	1,389.5	0.168	1,939.0	0.171	63.2	0.027	100.4	1,869.9	0.027
2 pane	62.6	0.091	41.5	538.2	0.091	833.7	0.091	26.0	0.017	41.5	797.0	0.017
Code	5.7	0.003	12.9	170.2	0.003	195.6	0.003	7.3	0.000	12.9	197.0	0.000

NYC

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	184.9	0.188	56.6	830.1	0.184	1,163.5	0.188	61.7	0.000	56.6	1,040.4	0.000
2 pane	94.1	0.097	21.7	347.3	0.094	482.7	0.097	28.2	0.000	21.7	416.8	0.000
Code	4.6	0.003	8.7	84.5	0.003	125.1	0.003	4.3	0.000	8.7	124.8	0.000

Poughkeepsie

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	147.8	0.158	74.3	1,015.5	0.154	1,345.2	0.158	65.1	0.030	74.3	1,262.5	0.030
2 pane	74.1	0.077	30.3	434.3	0.077	589.0	0.077	29.4	0.013	30.3	544.4	0.013
Code	5.8	0.000	11.8	114.4	0.000	147.9	0.000	6.2	0.000	11.8	148.4	0.000

Syracuse

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	147.7	0.225	90.1	1,330.8	0.218	1,689.9	0.225	67.1	0.050	90.1	1,609.5	0.050
2 pane	71.2	0.117	38.1	567.5	0.114	723.8	0.117	29.5	0.034	38.1	682.1	0.034
Code	6.6	0.007	11.7	134.6	0.007	174.6	0.007	7.2	0.000	11.7	175.2	0.000

COMMERCIAL HIGH PERFORMANCE WINDOWS

High-Performance Windows – Assembly

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2,222	0.156	0.0
	AC with gas heat	270	0.156	86.5
	Air source heat pump	1,951	0.156	0.0
	Electric heat only	1,992	0.000	0.0
	Gas heat only	0	0.000	86.5
Binghamton	AC with electric heat	2,345	0.156	0.0
	AC with gas heat	220	0.156	96.6
	Air source heat pump	2,278	0.156	0.0
	Electric heat only	2,163	0.000	0.0
	Gas heat only	0	0.000	96.6
Buffalo	AC with electric heat	2,169	0.156	0.0
	AC with gas heat	235	0.156	88.2
	Air source heat pump	1,703	0.156	0.0
	Electric heat only	1,985	0.000	0.0
	Gas heat only	0	0.000	88.2
Massena	AC with electric heat	4,296	0.156	0.0
	AC with gas heat	304	0.156	182.9
	Air source heat pump	3,878	0.156	0.0
	Electric heat only	4,083	0.000	0.0
	Gas heat only	0	0.000	182.9
NYC	AC with electric heat	1,048	0.156	0.0
	AC with gas heat	389	0.156	30.1
	Air source heat pump	825	0.156	0.0
	Electric heat only	714	0.000	0.0
	Gas heat only	0	0.000	30.1
Poughkeepsie	AC with electric heat	2,053	0.156	0.0
	AC with gas heat	262	0.156	83.4
	Air source heat pump	1,861	0.156	0.0
	Electric heat only	1,843	0.000	0.0
	Gas heat only	0	0.000	83.4
Syracuse	AC with electric heat	1,775	0.156	0.0
	AC with gas heat	267	0.156	68.7
	Air source heat pump	1,852	0.156	0.0
	Electric heat only	1,541	0.000	0.0
	Gas heat only	0	0.000	68.7

High-Performance Windows - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,714	0.156	0.0
	AC with gas heat	294	0.156	68.9
	Air source heat pump	1,520	0.156	0.0
	Electric heat only	1,563	0.000	0.0
	Gas heat only	0	0.000	68.9
Binghamton	AC with electric heat	1,493	0.156	0.0
	AC with gas heat	223	0.156	60.4
	Air source heat pump	1,596	0.156	0.0
	Electric heat only	1,324	0.000	0.0
	Gas heat only	0	0.000	60.4
Buffalo	AC with electric heat	1,794	0.156	0.0
	AC with gas heat	250	0.156	72.5
	Air source heat pump	1,454	0.156	0.0
	Electric heat only	1,594	0.000	0.0
	Gas heat only	0	0.000	72.5
Massena	AC with electric heat	1,934	0.156	0.0
	AC with gas heat	284	0.156	78.0
	Air source heat pump	1,750	0.156	0.0
	Electric heat only	1,751	0.000	0.0
	Gas heat only	0	0.000	78.0
NYC	AC with electric heat	860	0.156	0.0
	AC with gas heat	353	0.156	25.0
	Air source heat pump	735	0.156	0.0
	Electric heat only	561	0.000	0.0
	Gas heat only	0	0.000	25.0
Poughkeepsie	AC with electric heat	1,137	0.156	0.0
	AC with gas heat	273	0.156	41.0
	Air source heat pump	916	0.156	0.0
	Electric heat only	959	0.000	0.0
	Gas heat only	0	0.000	41.0
Syracuse	AC with electric heat	1,433	0.156	0.0
	AC with gas heat	281	0.156	54.0
	Air source heat pump	1,361	0.156	0.0
	Electric heat only	1,292	0.000	0.0
	Gas heat only	0	0.000	54.0

High-Performance Windows -Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2,032	0.156	0.0
	AC with gas heat	298	0.156	81.2
	Air source heat pump	1,504	0.156	0.0
	Electric heat only	1,810	0.000	0.0
	Gas heat only	0	0.000	81.2
Binghamton	AC with electric heat	2,086	0.156	0.0
	AC with gas heat	257	0.156	86.0
	Air source heat pump	1,544	0.156	0.0
	Electric heat only	1,814	0.000	0.0
	Gas heat only	0	0.000	86.0
Buffalo	AC with electric heat	2,302	0.156	0.0
	AC with gas heat	281	0.156	94.8
	Air source heat pump	1,703	0.156	0.0
	Electric heat only	1,789	0.000	0.0
	Gas heat only	0	0.000	94.8
Massena	AC with electric heat	2,158	0.156	0.0
	AC with gas heat	284	0.156	87.1
	Air source heat pump	1,597	0.156	0.0
	Electric heat only	1,845	0.000	0.0
	Gas heat only	0	0.000	87.1
NYC	AC with electric heat	1,694	0.156	0.2
	AC with gas heat	382	0.156	64.0
	Air source heat pump	1,254	0.156	0.0
	Electric heat only	1,905	0.000	0.0
	Gas heat only	0	0.000	64.0
Poughkeepsie	AC with electric heat	1,801	0.156	0.0
	AC with gas heat	308	0.156	71.9
	Air source heat pump	1,333	0.156	0.0
	Electric heat only	1,927	0.000	0.0
	Gas heat only	0	0.000	71.9
Syracuse	AC with electric heat	2,066	0.156	0.2
	AC with gas heat	303	0.156	83.1
	Air source heat pump	1,529	0.156	0.0
	Electric heat only	1,867	0.000	0.0
	Gas heat only	0	0.000	83.1

High-Performance Windows -Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2,670	0.156	0.0
	AC with gas heat	380	0.156	108.6
	Air source heat pump	1,976	0.156	0.0
	Electric heat only	2,426	0.000	0.0
	Gas heat only	0	0.000	108.6
Binghamton	AC with electric heat	2,778	0.156	0.0
	AC with gas heat	338	0.156	115.2
	Air source heat pump	2,056	0.156	0.0
	Electric heat only	2,614	0.000	0.0
	Gas heat only	0	0.000	115.2
Buffalo	AC with electric heat	2,977	0.156	0.0
	AC with gas heat	352	0.156	124.3
	Air source heat pump	2,203	0.156	0.0
	Electric heat only	2,751	0.000	0.0
	Gas heat only	0	0.000	124.3
Massena	AC with electric heat	2,812	0.156	0.0
	AC with gas heat	372	0.156	115.5
	Air source heat pump	2,081	0.156	0.0
	Electric heat only	2,618	0.000	0.0
	Gas heat only	0	0.000	115.5
NYC	AC with electric heat	2,325	0.156	0.0
	AC with gas heat	449	0.156	91.7
	Air source heat pump	1,721	0.156	0.0
	Electric heat only	2,068	0.000	0.0
	Gas heat only	0	0.000	91.7
Poughkeepsie	AC with electric heat	2,161	0.156	0.0
	AC with gas heat	373	0.156	87.6
	Air source heat pump	1,599	0.156	0.0
	Electric heat only	1,921	0.000	0.0
	Gas heat only	0	0.000	87.6
Syracuse	AC with electric heat	3,060	0.156	0.0
	AC with gas heat	407	0.156	127.3
	Air source heat pump	2,264	0.156	0.0
	Electric heat only	2,874	0.000	0.0
	Gas heat only	0	0.000	127.3

High-Performance Windows – Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,714	0.156	0.0
	AC with gas heat	294	0.156	68.9
	Air source heat pump	1,520	0.156	0.0
	Electric heat only	1,563	0.000	0.0
	Gas heat only	0	0.000	68.9
Binghamton	AC with electric heat	1,493	0.156	0.0
	AC with gas heat	223	0.156	60.4
	Air source heat pump	1,596	0.156	0.0
	Electric heat only	1,324	0.000	0.0
	Gas heat only	0	0.000	60.4
Buffalo	AC with electric heat	1,794	0.156	0.0
	AC with gas heat	250	0.156	72.5
	Air source heat pump	1,454	0.156	0.0
	Electric heat only	1,594	0.000	0.0
	Gas heat only	0	0.000	72.5
Massena	AC with electric heat	1,934	0.156	0.0
	AC with gas heat	284	0.156	78.0
	Air source heat pump	1,750	0.156	0.0
	Electric heat only	1,751	0.000	0.0
	Gas heat only	0	0.000	78.0
NYC	AC with electric heat	860	0.156	0.0
	AC with gas heat	353	0.156	25.0
	Air source heat pump	735	0.156	0.0
	Electric heat only	561	0.000	0.0
	Gas heat only	0	0.000	25.0
Poughkeepsie	AC with electric heat	1,137	0.156	0.0
	AC with gas heat	273	0.156	41.0
	Air source heat pump	916	0.156	0.0
	Electric heat only	959	0.000	0.0
	Gas heat only	0	0.000	41.0
Syracuse	AC with electric heat	1,433	0.156	0.0
	AC with gas heat	281	0.156	54.0
	Air source heat pump	1,361	0.156	0.0
	Electric heat only	1,292	0.000	0.0
	Gas heat only	0	0.000	54.0

High-Performance Windows – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	967	0.156	0.0
	AC with gas heat	239	0.156	34.6
	Air source heat pump	838	0.156	0.0
	Electric heat only	764	0.000	0.0
	Gas heat only	0	0.000	34.6
Binghamton	AC with electric heat	1,092	0.156	0.0
	AC with gas heat	200	0.156	40.4
	Air source heat pump	875	0.156	0.0
	Electric heat only	922	0.000	0.0
	Gas heat only	0	0.000	40.4
Buffalo	AC with electric heat	1,202	0.156	0.0
	AC with gas heat	233	0.156	48.3
	Air source heat pump	923	0.156	0.0
	Electric heat only	1,050	0.000	0.0
	Gas heat only	0	0.000	48.3
Massena	AC with electric heat	1,138	0.156	0.0
	AC with gas heat	219	0.156	43.6
	Air source heat pump	980	0.156	0.0
	Electric heat only	943	0.000	0.0
	Gas heat only	0	0.000	43.6
NYC	AC with electric heat	717	0.156	0.0
	AC with gas heat	318	0.156	19.6
	Air source heat pump	613	0.156	0.0
	Electric heat only	442	0.000	0.0
	Gas heat only	0	0.000	19.6
Poughkeepsie	AC with electric heat	636	0.156	0.0
	AC with gas heat	216	0.156	19.6
	Air source heat pump	521	0.156	0.0
	Electric heat only	450	0.000	0.0
	Gas heat only	0	0.000	19.6
Syracuse	AC with electric heat	974	0.156	0.0
	AC with gas heat	219	0.156	35.2
	Air source heat pump	837	0.156	0.0
	Electric heat only	781	0.000	0.0
	Gas heat only	0	0.000	35.2

High-Performance Windows –Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,828	0.156	0.0
	AC with gas heat	326	0.156	70.1
	Air source heat pump	1,478	0.156	0.0
	Electric heat only	1,572	0.000	0.0
	Gas heat only	0	0.000	70.1
Binghamton	AC with electric heat	1,863	0.156	0.0
	AC with gas heat	273	0.156	74.2
	Air source heat pump	1,580	0.156	0.0
	Electric heat only	1,636	0.000	0.0
	Gas heat only	0	0.000	74.2
Buffalo	AC with electric heat	1,977	0.156	0.0
	AC with gas heat	298	0.156	78.9
	Air source heat pump	1,489	0.156	0.0
	Electric heat only	1,714	0.000	0.0
	Gas heat only	0	0.000	78.9
Massena	AC with electric heat	2,382	0.156	0.0
	AC with gas heat	319	0.156	95.9
	Air source heat pump	2,000	0.156	0.0
	Electric heat only	2,130	0.000	0.0
	Gas heat only	0	0.000	95.9
NYC	AC with electric heat	1,243	0.156	0.0
	AC with gas heat	413	0.156	40.0
	Air source heat pump	941	0.156	0.0
	Electric heat only	953	0.000	0.0
	Gas heat only	0	0.000	40.0
Poughkeepsie	AC with electric heat	1,430	0.156	0.0
	AC with gas heat	312	0.156	53.0
	Air source heat pump	1,159	0.156	0.0
	Electric heat only	1,202	0.000	0.0
	Gas heat only	0	0.000	53.0
Syracuse	AC with electric heat	1,748	0.156	0.0
	AC with gas heat	326	0.156	66.9
	Air source heat pump	1,468	0.156	0.0
	Electric heat only	1,507	0.000	0.0
	Gas heat only	0	0.000	66.9

High-Performance Windows -Primary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,863	0.000	0.0
	AC with gas heat	554	0.000	57.6
	Air source heat pump	1,429	0.000	0.0
	Electric heat only	1,332	0.000	0.0
	Gas heat only	0	0.000	57.6
Binghamton	AC with electric heat	1,971	0.000	0.0
	AC with gas heat	470	0.000	66.3
	Air source heat pump	1,440	0.000	0.0
	Electric heat only	1,529	0.000	0.0
	Gas heat only	0	0.000	66.3
Buffalo	AC with electric heat	2,195	0.000	0.0
	AC with gas heat	531	0.000	74.0
	Air source heat pump	1,556	0.000	0.0
	Electric heat only	1,737	0.000	0.0
	Gas heat only	0	0.000	74.0
Massena	AC with electric heat	2,072	0.000	0.0
	AC with gas heat	518	0.000	67.7
	Air source heat pump	1,636	0.000	0.0
	Electric heat only	1,578	0.000	0.0
	Gas heat only	0	0.000	67.7
NYC	AC with electric heat	1,671	0.000	0.0
	AC with gas heat	692	0.000	44.4
	Air source heat pump	1,174	0.000	0.0
	Electric heat only	1,050	0.000	0.0
	Gas heat only	0	0.000	44.4
Poughkeepsie	AC with electric heat	1,380	0.000	0.0
	AC with gas heat	570	0.000	35.9
	Air source heat pump	1,125	0.000	0.0
	Electric heat only	780	0.000	0.0
	Gas heat only	0	0.000	35.9
Syracuse	AC with electric heat	1,958	0.000	0.0
	AC with gas heat	550	0.000	62.3
	Air source heat pump	1,468	0.000	0.0
	Electric heat only	1,438	0.000	0.0
	Gas heat only	0	0.000	62.3

High-Performance Windows -Religious Worship

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2,222	0.156	0.0
	AC with gas heat	270	0.156	86.5
	Air source heat pump	1,951	0.156	0.0
	Electric heat only	1,992	0.000	0.0
	Gas heat only	0	0.000	86.5
Binghamton	AC with electric heat	2,345	0.156	0.0
	AC with gas heat	220	0.156	96.6
	Air source heat pump	2,278	0.156	0.0
	Electric heat only	2,163	0.000	0.0
	Gas heat only	0	0.000	96.6
Buffalo	AC with electric heat	2,169	0.156	0.0
	AC with gas heat	235	0.156	88.2
	Air source heat pump	1,703	0.156	0.0
	Electric heat only	1,985	0.000	0.0
	Gas heat only	0	0.000	88.2
Massena	AC with electric heat	4,296	0.156	0.0
	AC with gas heat	304	0.156	182.9
	Air source heat pump	3,878	0.156	0.0
	Electric heat only	4,083	0.000	0.0
	Gas heat only	0	0.000	182.9
NYC	AC with electric heat	1,048	0.156	0.0
	AC with gas heat	389	0.156	30.1
	Air source heat pump	825	0.156	0.0
	Electric heat only	714	0.000	0.0
	Gas heat only	0	0.000	30.1
Poughkeepsie	AC with electric heat	2,053	0.156	0.0
	AC with gas heat	262	0.156	83.4
	Air source heat pump	1,861	0.156	0.0
	Electric heat only	1,843	0.000	0.0
	Gas heat only	0	0.000	83.4
Syracuse	AC with electric heat	1,775	0.156	0.0
	AC with gas heat	267	0.156	68.7
	Air source heat pump	1,852	0.156	0.0
	Electric heat only	1,541	0.000	0.0
	Gas heat only	0	0.000	68.7

High-Performance Windows -Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,169	0.156	0.0
	AC with gas heat	303	0.156	43.1
	Air source heat pump	829	0.156	0.0
	Electric heat only	855	0.000	0.0
	Gas heat only	0	0.000	43.1
Binghamton	AC with electric heat	1,225	0.156	0.0
	AC with gas heat	260	0.156	48.2
	Air source heat pump	842	0.156	0.0
	Electric heat only	948	0.000	0.0
	Gas heat only	0	0.000	48.2
Buffalo	AC with electric heat	1,300	0.156	0.0
	AC with gas heat	281	0.156	51.0
	Air source heat pump	877	0.156	0.0
	Electric heat only	1,024	0.000	0.0
	Gas heat only	0	0.000	51.0
Massena	AC with electric heat	1,349	0.156	0.0
	AC with gas heat	290	0.156	51.8
	Air source heat pump	1,021	0.156	0.0
	Electric heat only	1,052	0.000	0.0
	Gas heat only	0	0.000	51.8
NYC	AC with electric heat	942	0.156	0.0
	AC with gas heat	366	0.156	29.7
	Air source heat pump	639	0.156	0.0
	Electric heat only	581	0.000	0.0
	Gas heat only	0	0.000	29.7
Poughkeepsie	AC with electric heat	860	0.156	0.0
	AC with gas heat	282	0.156	29.0
	Air source heat pump	636	0.156	0.0
	Electric heat only	517	0.000	0.0
	Gas heat only	0	0.000	29.0
Syracuse	AC with electric heat	1,201	0.156	0.0
	AC with gas heat	310	0.156	44.7
	Air source heat pump	834	0.156	0.0
	Electric heat only	893	0.000	0.0
	Gas heat only	0	0.000	44.7

High-Performance Windows -Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,704	0.156	0.0
	AC with gas heat	357	0.156	65.4
	Air source heat pump	1,259	0.156	0.0
	Electric heat only	1,421	0.000	0.0
	Gas heat only	0	0.000	65.4
Binghamton	AC with electric heat	1,797	0.156	0.0
	AC with gas heat	320	0.156	72.2
	Air source heat pump	1,294	0.156	0.0
	Electric heat only	1,559	0.000	0.0
	Gas heat only	0	0.000	72.2
Buffalo	AC with electric heat	1,872	0.156	0.0
	AC with gas heat	327	0.156	75.2
	Air source heat pump	1,309	0.156	0.0
	Electric heat only	1,635	0.000	0.0
	Gas heat only	0	0.000	75.2
Massena	AC with electric heat	1,828	0.156	0.0
	AC with gas heat	329	0.156	71.9
	Air source heat pump	1,433	0.156	0.0
	Electric heat only	1,597	0.000	0.0
	Gas heat only	0	0.000	71.9
NYC	AC with electric heat	1,260	0.156	0.0
	AC with gas heat	437	0.156	40.8
	Air source heat pump	886	0.156	0.0
	Electric heat only	929	0.000	0.0
	Gas heat only	0	0.000	40.8
Poughkeepsie	AC with electric heat	1,085	0.156	0.0
	AC with gas heat	305	0.156	37.4
	Air source heat pump	821	0.156	0.0
	Electric heat only	819	0.000	0.0
	Gas heat only	0	0.000	37.4
Syracuse	AC with electric heat	1,810	0.156	0.0
	AC with gas heat	370	0.156	70.8
	Air source heat pump	1,321	0.156	0.0
	Electric heat only	1,546	0.000	0.0
	Gas heat only	0	0.000	70.8

High-Performance Windows -Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1,828	0.156	0.0
	AC with gas heat	326	0.156	70.1
	Air source heat pump	1,478	0.156	0.0
	Electric heat only	1,572	0.000	0.0
	Gas heat only	0	0.000	70.1
Binghamton	AC with electric heat	1,863	0.156	0.0
	AC with gas heat	273	0.156	74.2
	Air source heat pump	1,580	0.156	0.0
	Electric heat only	1,636	0.000	0.0
	Gas heat only	0	0.000	74.2
Buffalo	AC with electric heat	1,977	0.156	0.0
	AC with gas heat	298	0.156	78.9
	Air source heat pump	1,489	0.156	0.0
	Electric heat only	1,714	0.000	0.0
	Gas heat only	0	0.000	78.9
Massena	AC with electric heat	2,382	0.156	0.0
	AC with gas heat	319	0.156	95.9
	Air source heat pump	2,000	0.156	0.0
	Electric heat only	2,130	0.000	0.0
	Gas heat only	0	0.000	95.9
NYC	AC with electric heat	1,243	0.156	0.0
	AC with gas heat	413	0.156	40.0
	Air source heat pump	941	0.156	0.0
	Electric heat only	953	0.000	0.0
	Gas heat only	0	0.000	40.0
Poughkeepsie	AC with electric heat	1,430	0.156	0.0
	AC with gas heat	312	0.156	53.0
	Air source heat pump	1,159	0.156	0.0
	Electric heat only	1,202	0.000	0.0
	Gas heat only	0	0.000	53.0
Syracuse	AC with electric heat	1,748	0.156	0.0
	AC with gas heat	326	0.156	66.9
	Air source heat pump	1,468	0.156	0.0
	Electric heat only	1,507	0.000	0.0
	Gas heat only	0	0.000	66.9

WINDOW FILM

Window Film - Assembly

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	388	0.178	-84.0
Binghamton	AC with gas heat	333	0.178	-93.2
Buffalo	AC with gas heat	358	0.178	-82.0
Massena	AC with gas heat	346	0.178	-100.6
NYC	AC with gas heat	592	0.178	-58.3
Poughkeepsie	AC with gas heat	379	0.178	-92.2
Syracuse	AC with gas heat	426	0.178	-66.0

Window Film - Auto Repair

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	167	0.178	-72.4
Binghamton	AC with gas heat	138	0.178	-63.0
Buffalo	AC with gas heat	159	0.178	-67.7
Massena	AC with gas heat	155	0.178	-74.0
NYC	AC with gas heat	271	0.178	-77.2
Poughkeepsie	AC with gas heat	164	0.178	-84.3
Syracuse	AC with gas heat	169	0.178	-83.5

Window Film - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	407	0.178	-54.1
Binghamton	AC with gas heat	357	0.178	-57.5
Buffalo	AC with gas heat	378	0.178	-46.4
Massena	AC with gas heat	370	0.178	-58.5
NYC	AC with gas heat	538	0.178	-38.6
Poughkeepsie	AC with gas heat	402	0.178	-47.9
Syracuse	AC with gas heat	402	0.178	-53.6

Window Film - Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	290	0.178	-82.9
Binghamton	AC with gas heat	241	0.178	-84.5
Buffalo	AC with gas heat	263	0.178	-77.3
Massena	AC with gas heat	268	0.178	-85.2
NYC	AC with gas heat	393	0.178	-72.3
Poughkeepsie	AC with gas heat	282	0.178	-85.0
Syracuse	AC with gas heat	297	0.178	-75.9

Window Film - Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	296	0.178	-109.1
Binghamton	AC with gas heat	249	0.178	-111.0
Buffalo	AC with gas heat	265	0.178	-98.9
Massena	AC with gas heat	273	0.178	-109.4
NYC	AC with gas heat	403	0.178	-94.8
Poughkeepsie	AC with gas heat	297	0.178	-110.2
Syracuse	AC with gas heat	309	0.178	-98.3

Window Film - Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	407	0.178	-54.1
Binghamton	AC with gas heat	357	0.178	-57.5
Buffalo	AC with gas heat	378	0.178	-46.4
Massena	AC with gas heat	370	0.178	-58.5
NYC	AC with gas heat	538	0.178	-38.6
Poughkeepsie	AC with gas heat	402	0.178	-47.9
Syracuse	AC with gas heat	402	0.178	-53.6

Window Film – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	232	0.178	-71.6
Binghamton	AC with gas heat	175	0.178	-74.1
Buffalo	AC with gas heat	226	0.178	-62.1
Massena	AC with gas heat	189	0.178	-76.6
NYC	AC with gas heat	251	0.178	-68.4
Poughkeepsie	AC with gas heat	211	0.178	-67.5
Syracuse	AC with gas heat	211	0.178	-65.7

Window Film - Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	445	0.178	-29.0
Binghamton	AC with gas heat	396	0.178	-30.0
Buffalo	AC with gas heat	399	0.178	-27.5
Massena	AC with gas heat	411	0.178	-32.4
NYC	AC with gas heat	523	0.178	-19.8
Poughkeepsie	AC with gas heat	455	0.178	-23.7
Syracuse	AC with gas heat	426	0.178	-27.1

Window Film - Primary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	437	0.000	-105.6
Binghamton	AC with gas heat	300	0.000	-108.8
Buffalo	AC with gas heat	382	0.000	-96.8
Massena	AC with gas heat	383	0.000	-108.7
NYC	AC with gas heat	555	0.000	-98.0
Poughkeepsie	AC with gas heat	437	0.000	-107.6
Syracuse	AC with gas heat	415	0.000	-99.9

Window Film - Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	388	0.178	-84.0
Binghamton	AC with gas heat	333	0.178	-93.2
Buffalo	AC with gas heat	358	0.178	-82.0
Massena	AC with gas heat	346	0.178	-100.6
NYC	AC with gas heat	592	0.178	-58.3
Poughkeepsie	AC with gas heat	379	0.178	-92.2
Syracuse	AC with gas heat	426	0.178	-66.0

Window Film - Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	342	0.178	-73.6
Binghamton	AC with gas heat	307	0.178	-73.9
Buffalo	AC with gas heat	307	0.178	-67.7
Massena	AC with gas heat	290	0.178	-83.6
NYC	AC with gas heat	448	0.178	-62.5
Poughkeepsie	AC with gas heat	319	0.178	-70.8
Syracuse	AC with gas heat	347	0.178	-69.6

Window Film - Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	516	0.178	-88.3
Binghamton	AC with gas heat	421	0.178	-93.5
Buffalo	AC with gas heat	444	0.178	-80.6
Massena	AC with gas heat	462	0.178	-82.0
NYC	AC with gas heat	613	0.178	-83.8
Poughkeepsie	AC with gas heat	509	0.178	-93.1
Syracuse	AC with gas heat	525	0.178	-86.1

Window Film - Other

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	360	0.178	-75.7
Binghamton	AC with gas heat	301	0.178	-78.4
Buffalo	AC with gas heat	326	0.178	-69.6
Massena	AC with gas heat	322	0.178	-80.8
NYC	AC with gas heat	476	0.178	-64.2
Poughkeepsie	AC with gas heat	353	0.178	-76.9
Syracuse	AC with gas heat	363	0.178	-70.4

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APPENDIX G

EQUIVALENT FULL-LOAD HOURS (EFLH), FOR HEATING AND COOLING

Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[786] study, with adjustments made for local building practices and climate.

Four separate models were created to represent general vintages of buildings:

1. Built prior to 1940, uninsulated masonry buildings. This vintage is referred to as "Pre-war uninsulated brick "

2. Built prior to 1979 when the NYS Energy Code (known as the Energy Conservation Construction Code of New York State – ECCCNYS) went into effect, poorly insulated wood-frame buildings This vintage is referred to as "Prior to 1979"

3. Built from 1979 through 2006, with insulation conforming to 1980s era building codes (1979 ECCCNYS.) This vintage is referred to as "From 1979 through 2006."

4. Built from 2007 through the present, new construction with insulation conforming to the 2007 ECCCNYS for residential buildings and the New York City Energy Conservative Construction Code (if applicable.) This vintage is referred to as "From 2007 through the present."

Heating equivalent full-load hours for residential buildings were originally calculated from a DOE-2.2 simulation of prototypical residential buildings. The prototype building characteristics are described in Appendix A. The revised heating EFLH are shown below:[787]

SINGLE-FAMILY DETACHED COOLING EFLH BY VINTAGE AND CITY

City	Old	Average	New
Albany	322	310	279
Binghamton	199	197	158
Buffalo	334	322	276
Massena	258	250	210
NYC	670	649	630
Poughkeepsie	496	470	464
Syracuse	310	296	268

[786] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

[787] The original EFLH numbers have been adjusted according to the recommendations contained in the statewide evaluation performed by Opinion Dynamics, New York Statewide Residential Gas High-Efficiency Heating Equipment Programs – Evaluation of 2009-2011 Programs, August 2014. Recommendations regarding EFLH hours located on page 81.

MULTI-FAMILY LOW-RISE COOLING EFLH BY VINTAGE AND CITY

City	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	286	295	279
Binghamton	217	219	210
Buffalo	270	274	256
Massena	230	228	218
NYC	507	550	562
Poughkeepsie	397	423	421
Syracuse	265	284	297

MULTI-FAMILY HIGH-RISE COOLING EFLH BY VINTAGE AND CITY[788]

City	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	594	647	782
Binghamton	479	539	684
Buffalo	572	637	773
Massena	532	571	668
NYC	793	843	954
Poughkeepsie	626	669	812
Syracuse	592	665	845

SINGLE-FAMILY DETACHED HEATING EFLH BY VINTAGE AND CITY

City	Old	Average	New
Albany	1,042	978	925
Binghamton	1,086	1,029	963
Buffalo	1,072	1,032	957
Massena	1,125	1,061	1,009
NYC	867	786	725
Poughkeepsie	931	862	807
Syracuse	1,098	1,042	972

MULTI-FAMILY LOW-RISE HEATING EFLH BY VINTAGE AND CITY

City	Pre-war uninsulated brick	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	1,111	1,030	1,012	729
Binghamton	1,397	1,320	1,245	899
Buffalo	1,281	1,219	1,215	883
Massena	1,433	1,306	1,326	964
NYC[789]	999	757	723	503
Poughkeepsie	857	894	868	616
Syracuse	1,395	1,175	1,206	845

[788] Note, there are no cooling values for the "Pre-war uninsulated brick vintage, due to a typical lack of any central cooling. This vintage assumes one room air conditioner (RAC) within the unit. For the savings calculation method, see the Air Conditioner – Room (RAC) measure listed in the Single and Multi-family Residential Measures section of this manual.

[789] NYC building only incorporates a higher thermostatic set point of 73ºF instead of 70 ºF based on reported data. The other cities listed use the thermostatic set-point of 70^0 F. Overheating in Hot Water and Steam-Heated Multi-family Buildings, U.S. Dept. of Energy, Jordan Dentz, Kapil Varshney and Hugh Henderson, October 2013.

MULTI-FAMILY HIGH-RISE HEATING EFLH BY VINTAGE AND CITY

City	Pre-war uninsulated brick	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	975	786	626	363
Binghamton	1,102	1,006	831	484
Buffalo	1,181	966	813	471
Massena	1,111	1,016	873	552
NYC[790]	1,012	526	395	219
Poughkeepsie	922	656	510	291
Syracuse	1,063	889	787	474

[790] IBID

SMALL COMMERCIAL COOLING EFLH

Building	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Assembly	478	436	497	415	669	574	506
Auto Repair	272	244	264	223	426	302	298
Big Box Retail	769	760	826	688	1,279	1,024	831
Fast Food Restaurant	512	501	519	436	645	579	544
Full Service Restaurant	437	514	460	389	574	506	466
Grocery	769	760	826	688	1,279	1,024	831
Light Industrial	400	435	423	370	549	475	429
Motel	734	959	1,084	997	1,233	1,143	1,072
Primary School	297	264	244	257	394	346	274
Religious Worship	227	1,006	190	204	279	230	246
Small Office	742	714	745	671	955	849	768
Small Retail	642	644	666	599	882	762	678
Warehouse	234	194	212	228	400	284	243
Other	501	572	535	474	736	623	553

LARGE COMMERCIAL COOLING EFLH

Building	System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Community College	CAV econ	585	433	520	509	846	706	609
	CAV noecon	773	586	693	692	1,128	997	811
	VAV econ	470	376	456	353	658	532	455
Dormitory[791]	Fan Coil*	736	657	752	693	800	760	763
High School	CAV econ	348	304	323	318	466	407	388
	CAV noecon	713	727	741	727	861	787	764
	VAV econ	237	203	215	215	341	289	256
Hospital	CAV econ	1,038	918	1,114	1,038	1,424	1,231	1,147
	CAV noecon	1,728	1,662	1,908	1,730	2,237	1,983	1,906
	VAV econ	961	855	1,026	962	1,217	1,089	1,050
Hotel	CAV econ	2,744	3,078	2,744	2,807	2,918	3,039	3,471
	CAV noecon	2,945	3,270	2,945	3,021	3,108	3,253	3,653
	VAV econ	2,702	3,046	2,702	2,745	2,929	2,937	3,437
Large Office	CAV econ	706	534	587	610	720	713	667
	CAV noecon	1,894	1,786	2,016	1,827	2,250	2,072	2,156
	VAV econ	623	519	504	505	716	670	572

[791] Dormitories consist of individual rooms with small heating/cooling coils. Constant Air Volume (CAV) or Variable Air Volume (VAV) with Economizers (econ) are not typically used.

Building	System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Large Retail	CAV econ	858	721	849	753	1,068	920	858
	CAV noecon	1,656	1,613	1,763	1,545	1,751	1,670	1,656
	VAV econ	704	594	713	611	886	757	704
University	CAV econ	680	496	610	567	882	706	699
	CAV noecon	936	723	870	811	1,208	1,030	951
	VAV econ	526	432	518	413	690	568	523

SMALL COMMERCIAL HEATING EFLH

Building	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Assembly	961	1,006	990	1,158	603	782	903
Auto Repair	3,325	3,455	3,331	3,649	1,910	2,642	3,271
Big Box Retail	554	509	557	620	191	373	522
Fast Food Restaurant	1,426	1,526	1,491	1,690	813	1,120	1,351
Full Service Restaurant	1,502	1,602	1,567	1,746	821	1,162	1,419
Grocery	554	509	557	620	191	373	522
Light Industrial	1,278	1,320	1,188	1,286	714	996	1,200
Motel	1,037	787	789	832	619	603	778
Primary School	1,300	1,290	1,357	1,311	840	1,070	1,236
Religious Worship	954	202	978	1,015	722	802	962
Small Office	747	793	760	861	431	589	750
Small Retail	984	1,006	1,020	1,134	545	765	969
Warehouse	916	1,023	940	1,094	452	642	888
Other	1,195	1,156	1,194	1,309	681	917	1,136

LARGE COMMERCIAL HEATING EFLH

Building	System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Community College	CAV econ	1,111	1,072	1,047	1,301	1,431	1,171	1,259
	CAV noecon	1,052	1,042	1,006	1,177	1,268	1,050	1,177
	VAV econ	607	1,161	1,040	606	434	389	554
Dormitory*	Fan Coil*	594	678	753	687	465	507	673
High School	CAV econ	776	782	808	822	901	898	960
	CAV noecon	701	725	741	759	840	829	902
	VAV econ	326	300	384	382	268	303	395
Hospital	CAV econ	3,084	2,847	2,897	2,782	3,366	2,886	3,062
	CAV noecon	2,733	2,423	2,516	2,353	3,137	2,514	2,704
	VAV econ	763	766	642	739	296	481	771
Hotel	CAV econ	1,230	1,177	1,220	1,239	1,077	1,054	1,175
	CAV noecon	962	907	941	1,032	753	794	919
	VAV econ	552	482	518	661	229	376	464

Building	System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Large Office	CAV econ	2,136	2,047	2,020	2,349	2,034	2,142	2,218
	CAV noecon	2,097	1,965	1,976	2,307	2,072	2,133	2,219
	VAV econ	484	476	485	544	291	367	441
Large Retail	CAV econ	2,167	2,148	2,147	2,243	2,101	2,030	2,144
	CAV noecon	2,057	1,983	2,015	2,106	2,033	1,913	2,030
	VAV econ	859	735	777	927	664	632	783
University	CAV econ	1,464	1,573	1,531	1,589	1,191	1,352	1,390
	CAV noecon	1,439	1,438	1,461	1,456	1,104	1,308	1,356
	VAV econ	1,060	569	1,206	1,224	684	761	624

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0	10/15/2010
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APPENDIX H

HVAC DISTRIBUTION EFFICIENCIES

Single-family Distribution System Efficiency in Heating Mode, Ducts Located in Unconditioned Basement

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.951	0.946	0.947	0.949	0.957	0.949
15%	Uninsulated	0.941	0.936	0.939	0.940	0.946	0.941
20%	Uninsulated	0.936	0.931	0.932	0.933	0.939	0.934
25%	Uninsulated	0.929	0.924	0.925	0.928	0.934	0.929
30%	Uninsulated	0.924	0.919	0.920	0.922	0.926	0.922
8%	R-6	0.980	0.979	0.978	0.978	0.980	0.979
15%	R-6	0.968	0.967	0.967	0.967	0.969	0.967
20%	R-6	0.959	0.959	0.959	0.960	0.962	0.960
25%	R-6	0.953	0.952	0.952	0.951	0.954	0.951
30%	R-6	0.946	0.944	0.944	0.944	0.946	0.944

Single-family Distribution System Efficiency in Cooling Mode, Ducts Located in Unconditioned Basement

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.969	0.964	0.958	0.974	0.973	0.975
15%	Uninsulated	0.959	0.952	0.952	0.974	0.967	0.967
20%	Uninsulated	0.956	0.945	0.946	0.968	0.959	0.961
25%	Uninsulated	0.948	0.939	0.938	0.966	0.955	0.956
30%	Uninsulated	0.946	0.938	0.934	0.960	0.948	0.950
8%	R-6	0.985	0.987	0.982	0.985	0.987	0.987
15%	R-6	0.972	0.976	0.968	0.976	0.976	0.977
20%	R-6	0.966	0.964	0.959	0.965	0.970	0.972
25%	R-6	0.960	0.961	0.954	0.959	0.967	0.966
30%	R-6	0.956	0.957	0.948	0.965	0.958	0.960

Residential Distribution System Efficiency in Heating Mode (Attic Ducts)

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse	Poughkeepsie
8%	Uninsulated	0.777	0.754	0.770	0.759	0.818	0.778	0.779
15%	Uninsulated	0.715	0.692	0.708	0.693	0.761	0.716	0.717
20%	Uninsulated	0.668	0.646	0.662	0.644	0.717	0.670	0.671
25%	Uninsulated	0.619	0.599	0.614	0.592	0.673	0.622	0.623
30%	Uninsulated	0.568	0.549	0.564	0.539	0.626	0.571	0.573
8%	R-6	0.910	0.907	0.910	0.905	0.920	0.911	0.911
15%	R-6	0.851	0.848	0.851	0.843	0.865	0.852	0.851
20%	R-6	0.806	0.804	0.807	0.796	0.823	0.808	0.807
25%	R-6	0.760	0.759	0.762	0.748	0.780	0.762	0.761
30%	R-6	0.712	0.711	0.715	0.698	0.735	0.714	0.714

Residential Distribution System Efficiency in Cooling Mode (Attic Ducts)

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse	Poughkeepsie
8%	Uninsulated	0.813	0.793	0.820	0.809	0.834	0.811	0.810
15%	Uninsulated	0.755	0.737	0.768	0.753	0.777	0.758	0.753
20%	Uninsulated	0.716	0.698	0.732	0.715	0.737	0.717	0.713
25%	Uninsulated	0.676	0.660	0.694	0.673	0.696	0.677	0.672
30%	Uninsulated	0.637	0.621	0.656	0.634	0.657	0.637	0.632
8%	R-6	0.916	0.914	0.922	0.916	0.919	0.918	0.916
15%	R-6	0.860	0.860	0.870	0.859	0.861	0.862	0.861
20%	R-6	0.821	0.820	0.833	0.819	0.823	0.821	0.821
25%	R-6	0.780	0.780	0.795	0.781	0.782	0.783	0.780
30%	R-6	0.740	0.740	0.761	0.739	0.741	0.742	0.739

Multi-family Distribution System Efficiency in Heating Mode

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.821	0.817	0.819	0.813	0.843	0.822
15%	Uninsulated	0.794	0.791	0.793	0.785	0.816	0.795
20%	Uninsulated	0.774	0.773	0.774	0.765	0.797	0.775
25%	Uninsulated	0.754	0.754	0.755	0.744	0.778	0.756
30%	Uninsulated	0.735	0.736	0.735	0.724	0.758	0.736
8%	R-6	0.943	0.944	0.944	0.941	0.949	0.944
15%	R-6	0.913	0.915	0.915	0.909	0.920	0.914
20%	R-6	0.892	0.895	0.894	0.887	0.900	0.893
25%	R-6	0.870	0.874	0.873	0.864	0.879	0.871
30%	R-6	0.848	0.853	0.852	0.841	0.858	0.849

Multi-family Distribution System Efficiency in Cooling Mode

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.814	0.797	0.821	0.805	0.859	0.808
15%	Uninsulated	0.792	0.774	0.799	0.776	0.838	0.782
20%	Uninsulated	0.770	0.750	0.781	0.759	0.824	0.767
25%	Uninsulated	0.757	0.739	0.762	0.744	0.810	0.752
30%	Uninsulated	0.738	0.720	0.748	0.726	0.795	0.734
8%	R-6	0.941	0.936	0.945	0.938	0.951	0.939
15%	R-6	0.912	0.909	0.916	0.913	0.929	0.910
20%	R-6	0.893	0.890	0.899	0.889	0.911	0.888
25%	R-6	0.871	0.870	0.879	0.870	0.894	0.870
30%	R-6	0.852	0.851	0.863	0.849	0.876	0.851

Assembly Building Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.909	0.923	0.918	0.925	0.857	0.881
15%	Uninsulated	0.879	0.890	0.889	0.890	0.829	0.851
20%	Uninsulated	0.858	0.868	0.867	0.869	0.810	0.831
25%	Uninsulated	0.835	0.848	0.846	0.849	0.793	0.812
30%	Uninsulated	0.816	0.829	0.828	0.829	0.776	0.795
8%	R-6	0.951	0.961	0.959	0.956	0.896	0.915
15%	R-6	0.917	0.930	0.926	0.923	0.863	0.883
20%	R-6	0.895	0.906	0.902	0.901	0.841	0.861
25%	R-6	0.871	0.884	0.879	0.881	0.821	0.840
30%	R-6	0.849	0.862	0.860	0.862	0.801	0.819

Assembly Building Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.870	0.845	0.857	0.869	0.922	0.898
15%	Uninsulated	0.859	0.835	0.846	0.858	0.908	0.887
20%	Uninsulated	0.850	0.825	0.838	0.850	0.897	0.878
25%	Uninsulated	0.840	0.815	0.828	0.840	0.886	0.867
30%	Uninsulated	0.829	0.805	0.817	0.829	0.873	0.856
8%	R-6	0.948	0.930	0.936	0.951	0.986	0.980
15%	R-6	0.932	0.916	0.921	0.936	0.967	0.964
20%	R-6	0.920	0.904	0.909	0.924	0.954	0.951
25%	R-6	0.906	0.891	0.896	0.910	0.939	0.938
30%	R-6	0.892	0.877	0.882	0.896	0.924	0.923

Fast Food Restaurant Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.809	0.807	0.804	0.820	0.766	0.805
15%	Uninsulated	0.784	0.784	0.781	0.797	0.734	0.778
20%	Uninsulated	0.766	0.768	0.765	0.780	0.714	0.759
25%	Uninsulated	0.750	0.753	0.749	0.765	0.693	0.742
30%	Uninsulated	0.734	0.739	0.734	0.750	0.675	0.725
8%	R-6	0.901	0.904	0.901	0.905	0.875	0.898
15%	R-6	0.862	0.867	0.864	0.867	0.825	0.858
20%	R-6	0.836	0.844	0.840	0.844	0.794	0.831
25%	R-6	0.813	0.822	0.817	0.822	0.765	0.806
30%	R-6	0.791	0.801	0.796	0.801	0.739	0.783

Fast Food Restaurant Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.853	0.843	0.853	0.845	0.866	0.848
15%	Uninsulated	0.843	0.834	0.843	0.837	0.853	0.839
20%	Uninsulated	0.836	0.827	0.835	0.830	0.844	0.831
25%	Uninsulated	0.827	0.819	0.827	0.822	0.834	0.823
30%	Uninsulated	0.818	0.810	0.817	0.814	0.823	0.814
8%	R-6	0.950	0.950	0.953	0.948	0.945	0.947
15%	R-6	0.933	0.935	0.937	0.932	0.925	0.930
20%	R-6	0.921	0.924	0.925	0.919	0.911	0.917
25%	R-6	0.908	0.912	0.912	0.907	0.896	0.904
30%	R-6	0.895	0.899	0.898	0.894	0.881	0.891

Full Service Restaurant Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.816	0.821	0.816	0.819	0.797	0.810
15%	Uninsulated	0.789	0.797	0.791	0.794	0.765	0.782
20%	Uninsulated	0.770	0.781	0.775	0.776	0.743	0.763
25%	Uninsulated	0.753	0.765	0.760	0.759	0.721	0.745
30%	Uninsulated	0.736	0.750	0.745	0.744	0.701	0.728
8%	R-6	0.904	0.910	0.905	0.902	0.893	0.901
15%	R-6	0.866	0.876	0.869	0.866	0.848	0.861
20%	R-6	0.840	0.853	0.847	0.841	0.818	0.834
25%	R-6	0.816	0.832	0.825	0.818	0.789	0.809
30%	R-6	0.794	0.812	0.805	0.797	0.763	0.786

Full Service Restaurant Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.827	0.827	0.840	0.814	0.854	0.821
15%	Uninsulated	0.825	0.826	0.839	0.813	0.845	0.819
20%	Uninsulated	0.821	0.824	0.836	0.811	0.837	0.815
25%	Uninsulated	0.818	0.821	0.832	0.808	0.829	0.812
30%	Uninsulated	0.813	0.817	0.827	0.804	0.820	0.807
8%	R-6	0.959	0.968	0.975	0.955	0.954	0.957
15%	R-6	0.955	0.970	0.975	0.953	0.941	0.952
20%	R-6	0.950	0.968	0.971	0.948	0.931	0.947
25%	R-6	0.943	0.963	0.966	0.942	0.919	0.940
30%	R-6	0.934	0.957	0.958	0.934	0.907	0.931

Small Retail Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.657	0.646	0.648	0.670	0.614	0.656
15%	Uninsulated	0.624	0.614	0.617	0.637	0.581	0.623
20%	Uninsulated	0.602	0.594	0.596	0.615	0.559	0.601
25%	Uninsulated	0.582	0.574	0.577	0.594	0.538	0.581
30%	Uninsulated	0.563	0.556	0.559	0.575	0.520	0.562
8%	R-6	0.792	0.787	0.788	0.798	0.767	0.789
15%	R-6	0.742	0.736	0.739	0.748	0.714	0.738
20%	R-6	0.710	0.704	0.707	0.716	0.679	0.705
25%	R-6	0.680	0.674	0.678	0.686	0.648	0.676
30%	R-6	0.652	0.646	0.652	0.659	0.619	0.648

Small Retail Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.825	0.822	0.825	0.816	0.838	0.817
15%	Uninsulated	0.818	0.817	0.819	0.809	0.827	0.810
20%	Uninsulated	0.812	0.812	0.813	0.804	0.818	0.804
25%	Uninsulated	0.805	0.806	0.807	0.798	0.809	0.797
30%	Uninsulated	0.798	0.800	0.800	0.791	0.799	0.790
8%	R-6	0.932	0.934	0.935	0.927	0.931	0.928
15%	R-6	0.921	0.926	0.924	0.917	0.915	0.916
20%	R-6	0.912	0.918	0.916	0.908	0.904	0.907
25%	R-6	0.903	0.910	0.907	0.899	0.891	0.897
30%	R-6	0.892	0.902	0.897	0.889	0.879	0.887

Other Building Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.798	0.799	0.797	0.809	0.759	0.788
15%	Uninsulated	0.769	0.771	0.770	0.780	0.727	0.759
20%	Uninsulated	0.749	0.753	0.751	0.760	0.707	0.739
25%	Uninsulated	0.730	0.735	0.733	0.742	0.686	0.720
30%	Uninsulated	0.712	0.719	0.717	0.725	0.668	0.703
8%	R-6	0.887	0.891	0.888	0.890	0.858	0.876
15%	R-6	0.847	0.852	0.850	0.851	0.813	0.835
20%	R-6	0.820	0.827	0.824	0.826	0.783	0.808
25%	R-6	0.795	0.803	0.800	0.802	0.756	0.783
30%	R-6	0.772	0.780	0.778	0.780	0.731	0.759

Other Building Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.844	0.834	0.844	0.836	0.870	0.846
15%	Uninsulated	0.836	0.828	0.837	0.829	0.858	0.839
20%	Uninsulated	0.830	0.822	0.831	0.824	0.849	0.832
25%	Uninsulated	0.823	0.815	0.824	0.817	0.840	0.825
30%	Uninsulated	0.815	0.808	0.815	0.810	0.829	0.817
8%	R-6	0.947	0.946	0.950	0.945	0.954	0.953
15%	R-6	0.935	0.937	0.939	0.935	0.937	0.941
20%	R-6	0.926	0.929	0.930	0.925	0.925	0.931
25%	R-6	0.915	0.919	0.920	0.915	0.911	0.920
30%	R-6	0.903	0.909	0.909	0.903	0.898	0.908

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-27	7/31/2013

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APPENDIX I

COOL ROOF

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Assembly	Albany	1,000 sq ft roof area	138	0.128	-16.0
	Binghamton	1,000 sq ft roof area	123	0.128	-16.0
	Buffalo	1,000 sq ft roof area	119	0.128	-16.0
	Massena	1,000 sq ft roof area	135	0.128	-19.0
	NYC	1,000 sq ft roof area	168	0.128	-11.0
	Poughkeepsie	1,000 sq ft roof area	163	0.128	-13.5
	Syracuse	1,000 sq ft roof area	150	0.128	-18.0
Auto Repair	Albany	1,000 sq ft roof area	77	0.128	-23.0
	Binghamton	1,000 sq ft roof area	66	0.128	-20.2
	Buffalo	1,000 sq ft roof area	65	0.128	-20.0
	Massena	1,000 sq ft roof area	78	0.128	-23.3
	NYC	1,000 sq ft roof area	116	0.128	-20.8
	Poughkeepsie	1,000 sq ft roof area	95	0.128	-21.9
	Syracuse	1,000 sq ft roof area	89	0.128	-21.9
Big Box Retail	Albany	1,000 sq ft roof area	155	0.128	-11.0
	Binghamton	1,000 sq ft roof area	146	0.128	-10.5
	Buffalo	1,000 sq ft roof area	132	0.128	-10.0
	Massena	1,000 sq ft roof area	150	0.128	-14.0
	NYC	1,000 sq ft roof area	187	0.128	-6.0
	Poughkeepsie	1,000 sq ft roof area	183	0.128	-8.5
	Syracuse	1,000 sq ft roof area	165	0.128	-12.0
Fast Food	Albany	1,000 sq ft roof area	117	0.128	-28.0
	Binghamton	1,000 sq ft roof area	101	0.128	-26.0
	Buffalo	1,000 sq ft roof area	101	0.128	-24.0
	Massena	1,000 sq ft roof area	124	0.128	-25.0
	NYC	1,000 sq ft roof area	170	0.128	-19.0
	Poughkeepsie	1,000 sq ft roof area	143	0.128	-23.5
	Syracuse	1,000 sq ft roof area	131	0.128	-28.0
Full Service Restaurant	Albany	1,000 sq ft roof area	279	0.128	-47.0
	Binghamton	1,000 sq ft roof area	112	0.128	-43.5
	Buffalo	1,000 sq ft roof area	233	0.128	-40.0
	Massena	1,000 sq ft roof area	282	0.128	-47.0
	NYC	1,000 sq ft roof area	344	0.128	-30.0
	Poughkeepsie	1,000 sq ft roof area	160	0.128	-38.5
	Syracuse	1,000 sq ft roof area	307	0.128	-47.0
Grocery	Albany	1,000 sq ft roof area	155	0.128	-11.0
	Binghamton	1,000 sq ft roof area	146	0.128	-10.5
	Buffalo	1,000 sq ft roof area	132	0.128	-10.0
	Massena	1,000 sq ft roof area	150	0.128	-14.0
	NYC	1,000 sq ft roof area	187	0.128	-6.0
	Poughkeepsie	1,000 sq ft roof area	183	0.128	-8.5
	Syracuse	1,000 sq ft roof area	165	0.128	-12.0

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Light Industrial	Albany	1,000 sq ft roof area	90	0.128	-20.0
	Binghamton	1,000 sq ft roof area	62	0.128	-19.0
	Buffalo	1,000 sq ft roof area	74	0.128	-18.0
	Massena	1,000 sq ft roof area	87	0.128	-21.0
	NYC	1,000 sq ft roof area	118	0.128	-14.0
	Poughkeepsie	1,000 sq ft roof area	94	0.128	-17.0
	Syracuse	1,000 sq ft roof area	102	0.128	-20.0
Motel	Albany	1,000 sq ft roof area	225	0.128	-10.0
	Binghamton	1,000 sq ft roof area	196	0.128	-8.8
	Buffalo	1,000 sq ft roof area	224	0.128	-11.3
	Massena	1,000 sq ft roof area	238	0.128	-6.3
	NYC	1,000 sq ft roof area	232	0.128	-10.9
	Poughkeepsie	1,000 sq ft roof area	207	0.128	-11.1
	Syracuse	1,000 sq ft roof area	250	0.128	-11.0
Primary School	Albany	1,000 sq ft roof area	196	0.624	-29.0
	Binghamton	1,000 sq ft roof area	145	0.086	-28.0
	Buffalo	1,000 sq ft roof area	152	0.426	-27.0
	Massena	1,000 sq ft roof area	191	0.116	-32.0
	NYC	1,000 sq ft roof area	270	0.652	-22.0
	Poughkeepsie	1,000 sq ft roof area	225	0.474	-25.5
	Syracuse	1,000 sq ft roof area	202	0.506	-33.0
Religious	Albany	1,000 sq ft roof area	138	0.128	-16.0
	Binghamton	1,000 sq ft roof area	123	0.128	-18.0
	Buffalo	1,000 sq ft roof area	120	0.128	-15.6
	Massena	1,000 sq ft roof area	135	0.128	-19.5
	NYC	1,000 sq ft roof area	168	0.128	-10.3
	Poughkeepsie	1,000 sq ft roof area	163	0.128	-19.7
	Syracuse	1,000 sq ft roof area	150	0.128	-18.8
Small Office	Albany	1,000 sq ft roof area	151	0.128	-12.0
	Binghamton	1,000 sq ft roof area	128	0.128	-11.5
	Buffalo	1,000 sq ft roof area	130	0.128	-11.0
	Massena	1,000 sq ft roof area	152	0.128	-14.0
	NYC	1,000 sq ft roof area	169	0.128	-8.0
	Poughkeepsie	1,000 sq ft roof area	164	0.128	-10.0
	Syracuse	1,000 sq ft roof area	157	0.128	-14.0
Small Retail	Albany	1,000 sq ft roof area	175	0.128	-17.0
	Binghamton	1,000 sq ft roof area	160	0.128	-16.0
	Buffalo	1,000 sq ft roof area	143	0.128	-15.0
	Massena	1,000 sq ft roof area	164	0.128	-21.0
	NYC	1,000 sq ft roof area	203	0.128	-12.0
	Poughkeepsie	1,000 sq ft roof area	195	0.128	-14.5
	Syracuse	1,000 sq ft roof area	184	0.128	-18.0
Warehouse	Albany	1,000 sq ft roof area	393	0.128	-48.4
	Binghamton	1,000 sq ft roof area	324	0.128	-56.4
	Buffalo	1,000 sq ft roof area	300	0.128	-44.7
	Massena	1,000 sq ft roof area	402	0.128	-47.4
	NYC	1,000 sq ft roof area	454	0.128	-38.6
	Poughkeepsie	1,000 sq ft roof area	464	0.128	-63.7
	Syracuse	1,000 sq ft roof area	440	0.128	-52.2

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Other	Albany	1,000 sq ft roof area	188	0.128	-25.0
	Binghamton	1,000 sq ft roof area	142	0.128	-21.9
	Buffalo	1,000 sq ft roof area	149	0.128	-20.2
	Massena	1,000 sq ft roof area	175	0.128	-23.0
	NYC	1,000 sq ft roof area	211	0.128	-16.7
	Poughkeepsie	1,000 sq ft roof area	188	0.128	-21.0
	Syracuse	1,000 sq ft roof area	193	0.128	-23.3

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010

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APPENDIX J

COMMERCIAL HVAC UNIT SAVINGS

AIR SIDE ECONOMIZER

Building Type	City	System Type	Unit	KWh/unit
Assembly	Albany	Air-Side Economizer	ton	39
	Binghamton	Air-Side Economizer	ton	36
	Buffalo	Air-Side Economizer	ton	45
	Massena	Air-Side Economizer	ton	33
	NYC	Air-Side Economizer	ton	27
	Poughkeepsie	Air-Side Economizer	ton	33
	Syracuse	Air-Side Economizer	ton	42
Big Box Retail	Albany	Air-Side Economizer	ton	165
	Binghamton	Air-Side Economizer	ton	152
	Buffalo	Air-Side Economizer	ton	167
	Massena	Air-Side Economizer	ton	138
	NYC	Air-Side Economizer	ton	152
	Poughkeepsie	Air-Side Economizer	ton	159
	Syracuse	Air-Side Economizer	ton	165
Fast Food	Albany	Air-Side Economizer	ton	49
	Binghamton	Air-Side Economizer	ton	47
	Buffalo	Air-Side Economizer	ton	53
	Massena	Air-Side Economizer	ton	44
	NYC	Air-Side Economizer	ton	39
	Poughkeepsie	Air-Side Economizer	ton	44
	Syracuse	Air-Side Economizer	ton	49
Full Service Restaurant	Albany	Air-Side Economizer	ton	38
	Binghamton	Air-Side Economizer	ton	35
	Buffalo	Air-Side Economizer	ton	41
	Massena	Air-Side Economizer	ton	32
	NYC	Air-Side Economizer	ton	31
	Poughkeepsie	Air-Side Economizer	ton	35
	Syracuse	Air-Side Economizer	ton	38
Light Industrial	Albany	Air-Side Economizer	ton	45
	Binghamton	Air-Side Economizer	ton	39
	Buffalo	Air-Side Economizer	ton	38
	Massena	Air-Side Economizer	ton	33
	NYC	Air-Side Economizer	ton	25
	Poughkeepsie	Air-Side Economizer	ton	35
	Syracuse	Air-Side Economizer	ton	54
Primary School	Albany	Air-Side Economizer	ton	49
	Binghamton	Air-Side Economizer	ton	44
	Buffalo	Air-Side Economizer	ton	52
	Massena	Air-Side Economizer	ton	38
	NYC	Air-Side Economizer	ton	42
	Poughkeepsie	Air-Side Economizer	ton	46
	Syracuse	Air-Side Economizer	ton	41

Building Type	City	System Type	Unit	KWh/unit
Small Office	Albany	Air-Side Economizer	ton	202
	Binghamton	Air-Side Economizer	ton	195
	Buffalo	Air-Side Economizer	ton	195
	Massena	Air-Side Economizer	ton	188
	NYC	Air-Side Economizer	ton	186
	Poughkeepsie	Air-Side Economizer	ton	194
	Syracuse	Air-Side Economizer	ton	186
Small Retail	Albany	Air-Side Economizer	ton	107
	Binghamton	Air-Side Economizer	ton	101
	Buffalo	Air-Side Economizer	ton	113
	Massena	Air-Side Economizer	ton	95
	NYC	Air-Side Economizer	ton	95
	Poughkeepsie	Air-Side Economizer	ton	101
	Syracuse	Air-Side Economizer	ton	111
Religious	Albany	Air-Side Economizer	ton	9
	Binghamton	Air-Side Economizer	ton	10
	Buffalo	Air-Side Economizer	ton	7
	Massena	Air-Side Economizer	ton	6
	NYC	Air-Side Economizer	ton	6
	Poughkeepsie	Air-Side Economizer	ton	7
	Syracuse	Air-Side Economizer	ton	6
Warehouse	Albany	Air-Side Economizer	ton	3
	Binghamton	Air-Side Economizer	ton	5
	Buffalo	Air-Side Economizer	ton	2
	Massena	Air-Side Economizer	ton	4
	NYC	Air-Side Economizer	ton	2
	Poughkeepsie	Air-Side Economizer	ton	4
	Syracuse	Air-Side Economizer	ton	7
Other	Albany	Air-Side Economizer	ton	71
	Binghamton	Air-Side Economizer	ton	66
	Buffalo	Air-Side Economizer	ton	71
	Massena	Air-Side Economizer	ton	61
	NYC	Air-Side Economizer	ton	61
	Poughkeepsie	Air-Side Economizer	ton	66
	Syracuse	Air-Side Economizer	ton	70

Close Approach Cooling Towers

Building Type	City	System Type	kWh/ton	kW/ton
Dormitory	Albany	Fan coil with Water Cooled Chiller	6.7	0.003
	Binghamton	Fan coil with Water Cooled Chiller	5.5	0.003
	Buffalo	Fan coil with Water Cooled Chiller	5.6	0.004
	Massena	Fan coil with Water Cooled Chiller	5.9	0.047
	NYC	Fan coil with Water Cooled Chiller	7.7	-0.006
	Poughkeepsie	Fan coil with Water Cooled Chiller	8.0	0.003
	Syracuse	Fan coil with Water Cooled Chiller	6.8	0.003

ECONOMIZER

Building Type	City	System type	kWh/ton	kW/ton
High School	Albany	CV no econ	5.7	0
		CV econ	1.8	0
		VAV econ	2.3	0
	Binghamton	CV no econ	5.9	0
		CV econ	2.2	0
		VAV econ	2.4	0
	Buffalo	CV no econ	5.6	0
		CV econ	1.8	0
		VAV econ	1.8	0
	Massena	CV no econ	5.9	0
		CV econ	1.8	0
		VAV econ	1.8	0
	NYC	CV no econ	6.3	0
		CV econ	2.3	0
		VAV econ	3.2	0
	Syracuse	CV no econ	5.9	0
		CV econ	2.2	0
		VAV econ	2.4	0
	Poughkeepsie	CV no econ	5.9	0
		CV econ	2.2	0
		VAV econ	2.4	0
Hotel	Albany	CV no econ	11.8	0
		CV econ	2.8	0
		VAV econ	3.5	0
	Binghamton	CV no econ	12.4	0
		CV econ	3.0	0
		VAV econ	3.5	0
	Buffalo	CV no econ	14.0	0
		CV econ	3.4	0
		VAV econ	3.6	0
	Massena	CV no econ	10.4	0
		CV econ	3.1	0
		VAV econ	3.9	0
	NYC	CV no econ	10.4	0
		CV econ	3.1	0
		VAV econ	3.9	0
	Syracuse	CV no econ	12.9	0
		CV econ	3.1	0
		VAV econ	3.6	0
	Poughkeepsie	CV no econ	11.1	0
		CV econ	3.0	0
		VAV econ	11.8	0

Building Type	City	System type	kWh/ton	kW/ton
Large Office	Albany	CV no econ	12.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	Binghamton	CV no econ	11.0	0
		CV econ	5.0	0
		VAV econ	5.0	0
	Buffalo	CV no econ	11.0	0
		CV econ	5.0	0
		VAV econ	6.0	0
	Massena	CV no econ	12.0	0
		CV econ	5.0	0
		VAV econ	5.0	0
	NYC	CV no econ	14.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	SPoughkeepsie	CV no econ	13.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	PSyracuse	CV no econ	11.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	Albany	CV no econ	14.0	0
		CV econ	9.0	0
		VAV econ	7.0	0
	Binghamton	CV no econ	14.0	0
		CV econ	8.0	0
		VAV econ	6.0	0
	Buffalo	CV no econ	14.0	0
		CV econ	8.0	0
		VAV econ	6.0	0
	Massena	CV no econ	13.0	0
		CV econ	8.0	0
		VAV econ	6.0	0
	NYC	CV no econ	16.0	0
		CV econ	10.0	0
		VAV econ	7.0	0
	Poughkeepsie	CV no econ	15.0	0
		CV econ	9.5	0
		VAV econ	7.0	0
	Syracuse	CV no econ	14.0	0
		CV econ	9.0	0
		VAV econ	6.0	0

Building Type	City	System type	kWh/ton	kW/ton
Large Retail	Albany	CV no econ	9.3	0
		CV econ	4.2	0
		VAV econ	6.3	0
	Binghamton	CV no econ	9.6	0
		CV econ	3.8	0
		VAV econ	4.9	0
	Buffalo	CV no econ	9.5	0
		CV econ	4.3	0
		VAV econ	5.6	0
	Massena	CV no econ	9.1	0
		CV econ	3.8	0
		VAV econ	6.0	0
	NYC	CV no econ	10.9	0
		CV econ	4.8	0
		VAV econ	8.6	0
	SPoughkeepsie	CV no econ	9.8	0
		CV econ	4.2	0
		VAV econ	7.1	0
	PSyracuse	CV no econ	9.1	0
		CV econ	4.0	0
		VAV econ	7.3	0
University	Albany	CV no econ	5.6	0
		CV econ	3.6	0
		VAV econ	4.1	0
	Binghamton	CV no econ	5.0	0
		CV econ	3.2	0
		VAV econ	3.3	0
	Buffalo	CV no econ	5.0	0
		CV econ	3.1	0
		VAV econ	3.8	0
	Massena	CV no econ	5.1	0
		CV econ	3.0	0
		VAV econ	3.8	0
	NYC	CV no econ	6.6	0
		CV econ	3.9	0
		VAV econ	5.7	0
	Poughkeepsie	CV no econ	6.7	0
		CV econ	3.6	0
		VAV econ	4.5	0
	PSyracuse	CV no econ	5.4	0
		CV econ	3.5	0
		VAV econ	4.1	0

Building Type	City	System type	kWh/ton	kW/ton
Other	Albany	CV no econ	9.7	0
		CV econ	4.4	0
		VAV econ	5.0	0
	Binghamton	CV no econ	9.6	0
		CV econ	4.2	0
		VAV econ	4.2	0
	Buffalo	CV no econ	9.9	0
		CV econ	4.3	0
		VAV econ	4.5	0
	Massena	CV no econ	9.3	0
		CV econ	4.1	0
		VAV econ	4.4	0
	NYC	CV no econ	10.7	0
		CV econ	4.9	0
		VAV econ	5.9	0
	Poughkeepsie	CV no econ	10.3	0
		CV econ	4.6	0
		VAV econ	5.3	0
	PSyracuse	CV no econ	9.7	0
		CV econ	4.5	0
		VAV econ	5.1	0

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APPENDIX K

VARIABLE FREQUENCY DRIVES

Unit energy (kWh) savings for VFDs were estimated by building type, HVAC type and city using DOE-2.2 simulations of the prototype buildings with built-up HVAC systems. The simulations were run for each of the three built-up system types (CV no economizer, CV with economizer, and VAV with economizer) and the results were weighted according to the HVAC system weights shown in Appendix B. The results for each prototype are shown by measure and location below:

Community College

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	606	683	497	429	452	216
Binghamton	716	682	496	510	534	256
Buffalo	663	631	460	471	495	237
Massena	553	835	383	390	412	197
NYC	419	399	290	293	312	150
Poughkeepsie	464	441	321	325	346	165
Syracuse	539	513	373	380	402	193

Dormitory

Climate	Measure Unit Savings (kWh/hp)			
	CW Pump	CHW Pump	HW Pump	Tower Fan
Albany	961	453	386	190
Binghamton	963	453	386	143
Buffalo	964	453	386	152
Massena	966	451	388	166
NYC	965	453	393	266
Poughkeepsie	962	450	387	244
Syracuse	966	452	388	204

High School

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	350	232	60	513	674	203
Binghamton	359	234	58	509	661	169
Buffalo	358	233	53	511	660	176
Massena	357	238	65	518	663	187
NYC	327	231	44	531	707	241
Poughkeepsie	348	232	54	522	699	209
Syracuse	346	236	59	527	692	210

Hospital

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	2,053	1,665	1,142	1,645	1,860	413
Binghamton	2,053	1,687	1,142	1,549	1,681	380
Buffalo	2,053	1,678	1,142	1,591	1,731	416
Massena	2,053	1,689	1,142	1,537	1,588	395
NYC	2,053	1,713	1,142	1,801	2,137	574
Poughkeepsie	2,053	1,718	1,142	1,694	1,977	487
Syracuse	2,053	1,671	1,142	1,618	1,796	415

Hotel

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	73	1,740	6,559	326	250	1,571
Binghamton	73	1,745	6,554	284	211	1,423
Buffalo	75	1,764	6,551	321	247	1,583
Massena	72	1,802	6,499	284	188	1,377
NYC	75	1,925	6,603	332	242	1,525
Poughkeepsie	73	2,198	6,563	286	201	1,475
Syracuse	74	1,854	6,556	295	209	1,497

Large Retail

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	1,049	3,421	3,287	1,085	1,282	280
Binghamton	1,059	3,481	3,241	1,074	1,266	217
Buffalo	1,062	3,462	3,270	1,082	1,272	240
Massena	1,053	3,448	3,246	1,080	1,257	251
NYC	1,020	3,310	3,411	1,091	1,310	396
Poughkeepsie	1,036	3,385	3,361	1,093	1,306	341
Syracuse	1,054	3,429	3,298	1,089	1,289	296

Office

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	1,334	1,231	981	1,286	1,646	269
Binghamton	1,315	1,195	905	1,156	1,463	233
Buffalo	1,299	1,196	938	1,154	1,467	255
Massena	1,382	1,258	981	1,315	1,625	248
NYC	1,183	1,176	845	1,258	1,605	407
Poughkeepsie	1,208	1,165	742	1,240	1,606	344
Syracuse	1,295	1,213	1,005	1,236	1,578	292

University

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	687	767	570	669	747	231
Binghamton	701	757	571	591	621	185
Buffalo	696	760	573	623	642	216
Massena	705	754	579	673	718	195
NYC	668	802	550	850	1,038	308
Poughkeepsie	683	775	558	789	959	261
Syracuse	680	771	572	685	738	251

For the city, measure, and building type combinations not addressed above, use data supplied by National Grid shown below. The unit savings estimates are based on data developed by NSTAR for the Massachusetts TRM[792]. These values were trued up to National Grid evaluation studies by computing the ratio of the savings by VFD application from the National Grid Massachusetts Energy Initiative program evaluation to the average value by application across the NSTAR data. This adjustment factor was then applied to each of the NSTAR values. The adjusted savings are shown below.

[792] NSTAR VFD savings taken from Chan, T. *Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR*, June, 2010

Measure Unit Savings (kWh/hp)

Building Type	Exh fan	CT fan	CHW pump	Boiler FW pump	HW pump	MAF	Return fan	Supply fan	WLHP circ pump
Elm/HSchool	1,968			1,492		2,088			1,334
Grocery	1,726	392	398	1,275	752	1,368	924	1,007	1,711
Health	1,863			1,812		1,842			1,912
Hotel/Motel	1,740			1,694		2,067			1,788
Multi-Family	1,768			1,806		1,892	902	1,025	1,934
Offices	1,840			1,440		2,054			1,685
Restaurant	1,899	424	381	1,526	916	1,613	936	1,059	1,845
Retail	1,707			1,504		1,469			1,561
University/College	2,011			1,788		1,976			1,594
Warehouse	1,828	195	199	1,545	934	1,982	823	936	1,468

Peak demand savings were taken from the NSTAR data, as shown below:

Measure Unit Demand Savings (kW/hp)

Building Type	Exh fan	CT fan	CHW pump	Boiler FW pump	HW pump	MAF	Return fan	Supply fan	WLHP circ pump
Elm/HSchool	0.411	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.300
Grocery	0.284	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.194
Health	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.061
Hotel/Motel	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.061
Multi-Family	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.061
Offices	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.061
Restaurant	0.284	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.194
Retail	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.061
University/College	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.070	0.061
Warehouse	0.119	-0.025	0.061	0.498	0.498	0.284	0.111	0.070	0.061

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APPENDIX L

MINIMUM MOTOR EFFICIENCY – EISA STANDARD

The Energy Independence and Security Act (EISA) of 2007 established NEMA Premium as the new standard for electric motor efficiency, effective December 2010. The energy savings baseline efficiency for all normal replacement motors rebated after the new standards take effect is shown below:

NEMA MG-1 Table 12-12 Full-Load Efficiencies for 60 Hz NEMA Premium® Efficient Electric Motors Rated 600 Volts or less (Random Wound)

Motor Horsepower	Nominal Full-Load Efficiency					
	Open Motors			Enclosed Motors		
	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole
1	77.0	85.5	82.5	77.0	85.5	82.5
1.5	84.0	86.5	86.5	84.0	86.5	87.5
2	85.5	86.5	87.5	85.5	86.5	88.5
3	85.5	89.5	88.5	86.5	89.5	89.5
5	86.5	89.5	89.5	88.5	89.5	89.5
7.5	88.5	91.0	90.2	89.5	91.7	91.0
10	89.5	91.7	91.7	90.2	91.7	91.0
15	90.2	93.0	91.7	91.0	92.4	91.7
20	91.0	93.0	92.4	91.0	93.0	91.7
25	91.7	93.6	93.0	91.7	93.6	93.0
30	91.7	94.1	93.6	91.7	93.6	93.0
40	92.4	94.1	94.1	92.4	94.1	94.1
50	93.0	94.5	94.1	93.0	94.5	94.1
60	93.6	95.0	94.5	93.6	95.0	94.5
75	93.6	95.0	94.5	93.6	95.4	94.5
100	93.6	95.4	95.0	94.1	95.4	95.0
125	94.1	95.4	95.0	95.0	95.4	95.0
150	94.1	95.8	95.4	95.0	95.8	95.8
200	95.0	95.8	95.4	95.4	96.2	95.8
250	95.0	95.8	95.4	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	95.8	96.2	96.2	95.8	96.2	95.8
500	95.8	96.2	96.2	95.8	96.2	95.8

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APPENDIX M

GUIDELINES FOR EARLY REPLACEMENT CONDITION

Getting Started

The full manual, beginning in Section 2, explains the concepts of the tables and their use, and the choices offered to PAs. It also contains various instructions on such matters as data retention and the tracking database. This first section contains the immediate directions to get a quick start on the simplest case. These tables can only be used regarding the proposed replacement of equipment that has not reached its prescribed Effective Useful Life (EUL). Two other conditions are pertinent to use of this page:

The PA accepts agrees to use the assumptions for each measure regarding the typical relationship between incremental costs and savings and the full costs and savings of replacing the older (but pre-EUL) equipment with the high efficiency equipment promoted by the program. The measures in question are listed in Table M-1 *without* an "a" or a "b" superscript.

If these conditions are met, the fundamental steps for calculation would be as follows:

- Calculate the full costs of replacing the old equipment with the program measure, including labor.
- Calculate the full first year savings of the program measure using the existing equipment as the baseline, assume such savings through the EUL of the new equipment, monetize the savings per the prescribed annual Long Run Avoided Costs (LRACs) estimates, and calculate the present value of this stream of monetized savings using Staff's discount rate. This present value is referred to herein as the Inflated Benefits.[793]
- Estimate the remaining useful life (RUL) of the old equipment in place.
- Turn to the measure-specific costs and savings tables of the measure in question (the measures are grouped by the EUL on Table M-1).
- Go down each table to the row for the estimated RUL and find the percentage adjustment factor in the column for the measure.
- Multiply the Inflated Benefits by the benefits factor.
- Multiply the full costs by the costs factor.
- For Total Resources Cost (TRC) analysis, use the two products from steps 6 and 7.
- For first year savings to report against approved program goals, use the full savings.

Introduction

In the EEPS Order issued on October 18, 2010 (p.9),[794] the Commission stated, regarding TRC analysis of early replacements in individual projects, that it was ". . . directing Staff to develop a new approach, based on the dual baseline approach, which provides consistency between the treatment of savings and costs. The Director of the Office of Energy Efficiency and Environment is directed to compile and provide simplifying lookup tables, which provide early

[793] "Inflated Benefits" is simply a concept designed to be an intermediate step in the computation of estimated dual baseline benefits, using the tables in this Appendix. It does not imply an assumption that the old equipment, absent the program, would have continued in use through the life of the new equipment.

[794] Case 07-M-0548, Order Approving Consolidation and Revision of Technical Manuals (issued October 18, 2010).

replacement method energy savings consistent with the dual baseline concept as an attachment to the consolidated Technical Manual (TM)." Staff was also directed "to develop a consistent cost estimation approach which reflects the concept that the costs of making a high efficiency early replacement will avoid an end-of useful-life replacement with minimally code compliant equipment."

Early Replacement vs. Normal Replacement

Early replacement is defined in the Order as the replacement of equipment before it reaches its Effective Useful Life (EUL), whereas end-of-life or normal replacement refers to the replacement of equipment that has reached or passed the end of its measure-prescribed EUL. The crucial difference between end-of-life replacement and early replacement is that end-of-life/normal uses "incremental" costs and savings while early replacement uses "full" values:

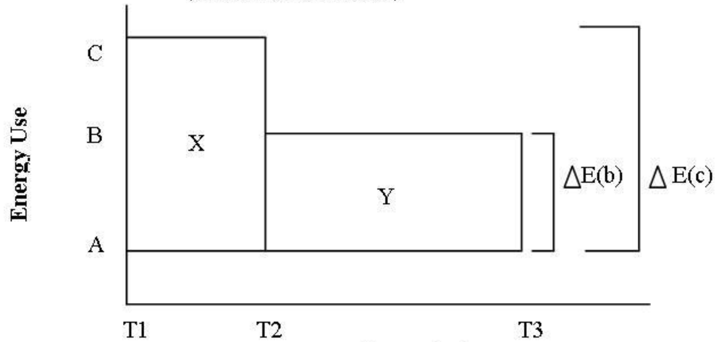
- *Incremental savings* is defined as the annual energy use of the currently-on-the-market standard, minimally compliant equipment minus the annual energy use of the high efficiency equipment subsidized by the program.
- *Full savings* is defined as the annual energy use of the old equipment in place minus the annual energy use of the high efficiency equipment subsidized by the program.
- *Incremental cost* is defined as the full cost of new efficient equipment minus the cost of the currently-on-the-market standard, minimally-compliant equipment, plus the time value penalty (the present value cost of a dollar amount increases with earlier spending, see below).
- *Full cost* is simply the cost (including installation) of the new efficient equipment.

Early replacement not only accelerates savings to the electric grid but also allows PAs to claim greater first-year annual savings toward their annual energy goals because full savings are reported as the first-year savings. *If a PA cannot substantiate that the age of the equipment in place is less than its EUL and therefore a case of early replacement,* the replacement must be screened as normal (end of life) replacement, with the incremental savings reported as the first-year savings toward approved program goals.

In both normal and early replacement conditions, the establishment of the correct baseline is critical in accurately estimating gross energy and demand impacts. However, while the TM addresses the establishment of the baseline for normal replacement conditions, it rarely addresses the establishment of baselines for early replacement conditions. This Appendix M provides two sets of lookup tables and guidance designed to simplify the complex mathematical analysis of dual-baseline cases and reduce PA data needs. The first set of tables, for *typical* early replacement measure conditions as developed by TecMarket Works, reflects data, discussed below, that PAs might find it difficult to obtain. The second set of tables requires PAs to provide these data but still simplifies the calculations.

The standard early replacement condition, illustrated in Figure 1, involves a customer who replaces equipment before it reaches the end of its EUL. That is, the equipment is fully functioning and would continue to function for some period of time; referred to as the remaining useful life (RUL). However, the customer is induced by the program to replace this existing equipment with more efficient equipment. It is assumed that at the end of the RUL, absent the program, the customer would have installed equipment that would meet the existing efficiency code or appliance standard, i.e., equipment that represents the market average efficiency or the efficiency that had become the industry standard (referred to as the *code/standard equipment*).

Figure 1. The Early Replacement Condition
(Use of Dual Baseline)



C = Energy use of pre-existing measure
B = Energy use of code/standard measure
A = Energy use of new efficient measure
T1 = Date on which new efficient measure is installed
T2 = Date on which existing measure was expected to have failed
T3 = Date on which the new efficient measure is expected to fail
T3—T1= Expected effective useful life (EUL) of the new efficient measure
T2—T1= Expected remaining useful life (RUL) of the pre-existing measure
T3 - T2 = Expected remaining EUL of the new efficient measure
Δ E(c) = The full savings defined as C - A
Δ E(b) = The incremental savings defined as B - A

Energy savings in this example would consist of two portions. The customer would have experienced the full savings defined by Area **X** (energy use C-A for the RUL period T2-T1). At the end of the RUL, the savings for the period T3-T2 would be reduced to incremental savings defined by area **Y**. To carry out these calculations, information on two (dual) baselines is required, the energy use of the pre-existing equipment and the energy use of code/standard equipment. Information on energy use for the high efficiency equipment provided through the program will also be required.

The cost would also have to be calculated in a manner consistent with early replacement. In normal replacement situations, one would use the incremental cost that is defined as the cost of the new efficient equipment minus the cost of the code/standard equipment. In the early replacement case, the incremental cost is calculated in a slightly different manner. This calculation recognizes that, while the customer purchased efficient equipment with the assistance of the program, it would have purchased code/standard equipment at some time in the future, i.e., at the end of the RUL, had the program not existed.

Thus, one would first have to determine the full cost of the new efficient equipment (including the installation labor) at T1 *and* the full cost of the code/standard equipment (including the installation labor) at T2. The incremental costs would then be calculated as the cost of the new efficient equipment minus the present value (PV) of the cost that is avoided in the future for the code/standard equipment. Figure 2 presents a case in which the RUL is 4 years and, absent the program, the code/standard equipment would have been installed in the fifth year. This calculation differs from the normal/end of life replacement incremental cost in adding the time value of money for spending earlier.

Figure 1. Incremental Cost Calculation for an Early Replacement of Equipment with an RUL of Four Years

Year	PV with Program	PV without Program
1	Full cost of high efficient equipment	0
2	0	0
3	0	0
4	0	0
5	0	Full cost of Code/Standard Equipment

The two key inputs necessary for these calculations, the energy use and the cost of the code/standard equipment, may not be readily available to PA field staff and are subject to change before the end of the equipment's RUL in the absence of a program. Note that the first set of tables in this Appendix M is based on current codes and standards. If a PA can document the needed energy use and cost data, it can choose to use the second set of tables. Both sets of tables are based on a "ratio approach".

The Ratio Approach to the Dual Baseline with the Lookup Tables

This approach focuses on the ratio of incremental savings to full savings[795] and the ratio of incremental costs to full costs. These ratios, shown at the top of the attached tables, determine the factors that PAs can use to adjust the savings and cost data they do have. The first set of tables, the measure-specific set, allows the early replacement calculations to be performed in a manner that only requires the program administrator to have the Remaining Useful Life (RUL) of the equipment in place and the full savings and costs of the project. The ratios in the first set of tables (M-2 through M-19) were developed by TecMarket Works. The second set of tables (M-29 through M-38), the non-measure-specific set, requires the program administrators to provide their own incremental costs and savings ratios (based on the code/standard equipment). To use the second set of tables, PAs must match ratios that they have calculated to corresponding ratios in the tables.

The source of these two ratios for the first set of tables is the Database for Energy Efficient Resources (DEER), most recently updated by Itron for the California Public Utility Commission in 2009. Among other things, DEER contains energy use and costs for selected energy-efficient technologies and equipment in the residential and nonresidential sectors. DEER also contains the same information for typical equipment, those commonly installed in the marketplace.

To use either set of tables PAs will need to calculate the first-year annual savings as the annual energy use of the old equipment in place minus the annual energy use of the high efficiency equipment (the full savings). These full savings are then counted for each year of the EUL as is

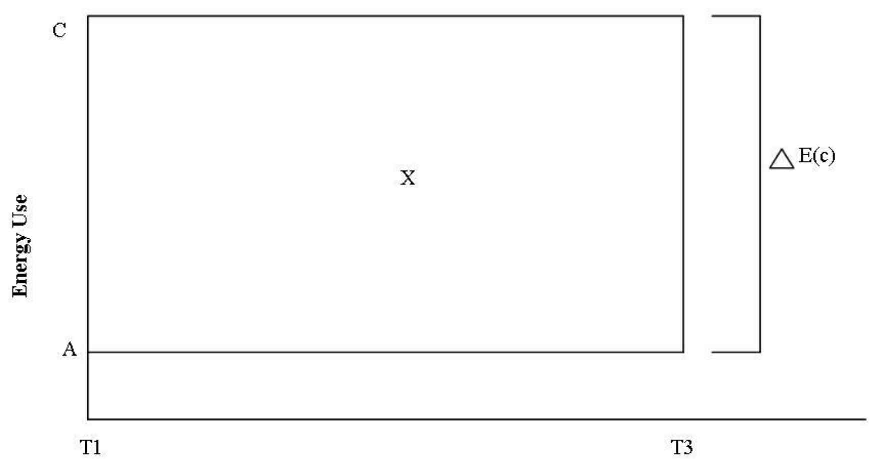
[795] The savings values ratios are not lifecycle present values but are rather the line segments in Figure 1 on the vertical axis: (B – A) divided by (C – A).

represented as area *X* in Figure 3. For each year of the EUL (T3 – T1) of the new equipment, the full kWh or therm savings are converted to dollar benefits by multiplying them by the Commission's avoided costs estimates for that year. As a preliminary step in using the tables, the PAs will calculate this "inflated lifecycle benefits" as the present value of the stream of full savings benefits for the EUL of the new equipment.

In cases of early replacement under the ratio approach, it is these inflated lifecycle benefits that must be adjusted using the appropriate *inflated lifecycle benefits adjustment factor*. For a given measure with a given EUL, RUL and ratio of incremental savings to full savings, the inflated lifecycle benefits adjustment factor is the ratio (presented as a percentage) of the present value of the dual baseline lifecycle benefits (X+Y) illustrated in Figure 1 to the present value of the inflated lifecycle benefits illustrated in Figure 3.

PAs can obtain these factors from either the set of DEER-based tables or from the set of PA-based tables if a PA can calculate its own incremental savings to full savings ratios.

Figure 3. Inflated Lifecycle Benefits



△E(c) = C - A
C = Energy use of pre-existing equipment
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T3 = Date on which the new efficient equipment is expected to fail
T3 - T1 = EUL of new efficient equipment

Under the Commission requirement of consistent treatment of savings and costs, the full costs[796] must also be adjusted downward. PAs can obtain the *full cost adjustment factors* from either the DEER-based Tables based on typical ratios of incremental cost to full cost or from the PA-based Tables if a PA can calculate its own incremental cost to full cost ratios. The DEER-based set of lookup tables runs from M-2 through M-28. Of these, M-2 through M-10 cover benefits, M-11 through M-19 costs, and M-20 through M-28 adjusted EULs. The PA-based set of lookup tables

796 Full costs include the capital cost of the new efficient equipment plus installation cost.

runs from M-29 through M-47. Of these, M-29 through M-37 cover benefits, M-38 all costs (only the RUL matters, not the EUL), and M-39 through M-47adjusted EULs.

DEER-Based Look-Up Tables

The first set of tables includes look-up tables M-2 through M-10, which present the *Inflated Lifecycle Benefit Adjustment Factors*. The tables are based primarily on data contained in the California 2009 DEER. For each qualified equipment type, the median ratio of incremental savings to the full savings was calculated. These ratios along with the RULs, ranging from 1 year to the EUL minus 1 year, are shown in the look-up tables and are used to derive the factors needed to adjust the inflated lifecycle benefits.

Tables M-11 through M-19 present the *full cost adjustment factors*, for the same equipment addressed in Tables M-2 through M-10, for the same RUL ranges. For each qualified equipment type, the median ratio of incremental costs to the full costs was calculated.

To use these tables of typical ratios, a PA must have gathered the following four pieces of information:

- the EUL of the new efficient equipment,
- the RUL of the old equipment in place,
- the full savings of the equipment (annual energy use of the old equipment in place minus the annual energy of the high efficiency equipment supported by the program), and
- the full costs (including installation)

The EUL for a given measure is obtained from Table M-1, which is a compilation of the EULs for all the relevant measures in the consolidated Technical Manual effective January 1, 2011 that could qualify for early replacement[797]. The RUL[798], the full savings, and the full costs are provided by the program implementer. Note that documentation for PA estimates of these data must be retained for possible Staff review. Table M-1 also presents the normal replacement baseline equipment against which each of the 29 measures covered in this table is compared. Note that the lookup tables apply only to the 23 measures without an ***a*** or ***b*** designation in Table M-1.

Table M-1. Early Replacement Measures, EULs, and Baselines

[797] Early replacement is inappropriate for such equipment as wall insulation, right sizing, setback thermostats, and sub-metering since nothing is being replaced. Lighting equipment has also been excluded since it is expected to be treated as pre-qualified.

[798] Upon request, Staff will provide a suggested questionnaire to assist in the determination of the RUL.

Measures	EUL	Normal Replacement Baseline
Heat Pump Water Heater: Residential	10	Code Electric Storage Water Heater
Room Air Conditioner: Residential	10	EPACT Room Air Conditioner
Clothes Washer: Single Family: Residential	11	EPACT Clothes Washer
ENERGY STAR Dishwashers: Residential	11	EPACT Dishwasher
Water Heater: Gas: Residential	11	Code Gas Storage Water Heater
Energy Star Dehumidifier: Residential[a]	12	Standard Efficiency Dehumidifier
Refrigerators: Nonresidential	12	EPACT Refrigerator
Indirect Water Heaters: Residential	13	Code Gas Storage Water Heater
Water Heater: Electric: Residential	13	Code Electric Storage Water Heater
Clothes Washer: Multi-Family Residential	14	EPACT Clothes Washer
Air Compressor Upgrade: Nonresidential	15	Standard Efficiency Rotary Screw Compressor
Central Air Conditioning: Residential	15	Code Central AC with gas heat
Central Air Source Heat Pumps: Residential	15	Code Central Air Source Heat Pump
Cool Roof: Nonresidential[a]	15	Standard Roof
Cooling Tower: Nonresidential[a]	15	Standard Efficiency Cooling Tower
Efficient Air-Cooled Refrigeration Condenser: Nonresidential[a]	15	Standard Efficiency Refrigeration Condenser
Indirect Water Heaters: Nonresidential	15	Code Gas Storage Water Heater
Motors: Nonresidential[b]	15	EISA Minimum Efficiency Motor
Packaged Air Conditioners (Central AC): Nonresidential	15	Code Packaged Air Conditioner
Packaged Air Source Heat Pumps (CAC Cooling Only): Nonresidenti	15	Code Packaged Air Source Heat Pump
Water Heaters: Nonresidential (Gas & Electric)	15	Code Storage Water Heater
Refrigerators: Residential	17	EPACT Refrigerator
Chillers: Nonresidential	20	Code Chiller
Gas Furnaces and Boilers: Nonresidential	20	Code Furnace and Boiler
High Efficiency Gas Furnaces: Residential	20	Code Furnace
High Performance Glazing: Nonresidential[b]	20	Code Glazing
High Performance Windows (Gas Heating Only): Residential	20	Code Window
Instantaneous Water Heater: Residential	20	Code Storage Water Heater
Gas Boilers: Residential	25	Code Boiler

EPACT refers to efficiency standards promulgated by the Energy Policy and Conservation Act of 2005

EISA refers to efficiency standards promulgated by the Energy Independence and Security Act of 2007

Code refers to New York State Construction codes, which reference ASHRAE standards.

For measures assigned an **a**, the efficiency of the old in place unit is still the common practice or no new standards have been adopted, i.e., the baseline for the full savings and the incremental savings are the same. As a result, the ratio of incremental to full savings is near 1.0, meaning that a PA can claim the full savings for the entire EUL of the new equipment (areas X and Y in Figure 4). Therefore, the lookup tables do not apply.

For these measures assigned a **b**, the high efficiency equipment subsidized by the program is consistent with current code or standards. For these measures, the incremental savings are zero and thus the ratio of incremental to full savings is 0.0.This means that a PA can claim full savings for only the RUL (area X in Figure 5), after which the high-efficiency replacement would have occurred anyway. Therefore, the lookup tables do not apply.

Figure 4. Efficiency of the Old In Place Unit Is Still the Common Practice Or No New Standards

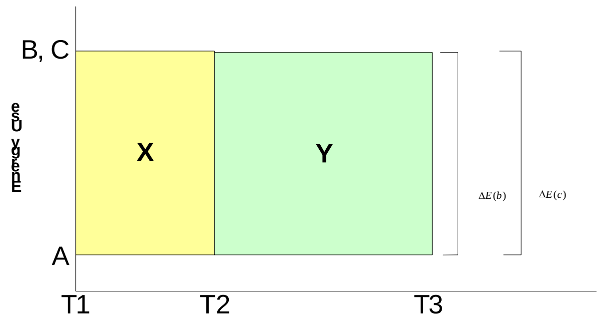
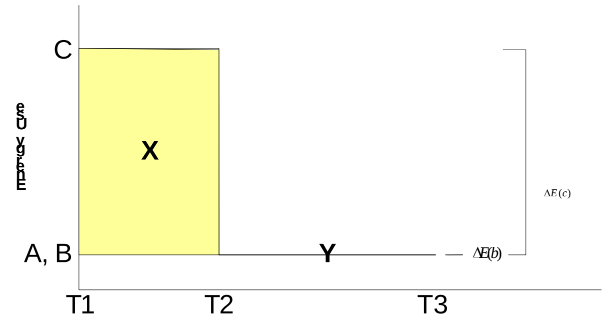


Figure 5. High Efficiency Equipment Subsidized by the Program Is Consistent with Current Code Or Standards



$\Delta E(c)$ = C - A

$\Delta E(b)$ = B - A

C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3= Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected remaining useful life (RUL) of the pre-existing equipment
T3 – T2 = Expected remaining EUL of the new efficient equipment

After obtaining the four pieces of information listed above, the program implementer can determine the appropriate inflated lifecycle benefits adjustment factor by which to multiply the inflated lifecycle benefits and the full cost adjustment factor by which to multiply the full costs. These adjusted inflated lifecycle benefits and adjusted full costs are to be used in the TRC ratio in the screening of measures in specific projects.

4.1.1 Table Organization

The DEER-Based Tables are divided into two groups:

- Inflated Lifecycle Benefit Adjustment Factors (Tables M-2 through M-10)
- Full-Cost Adjustment Factor (Tables M-11 through M-19)

Each set of tables addresses the same 23 measures or varieties of measures grouped by the EUL.

In each table, the left *column* contains the RULs from 1 year through the EUL minus 1 year. For example, Table M-5 presents Inflated Lifecycle Benefit Adjustment Factors for measures with an EUL of 15 years. Therefore, Table M-5 contains RULs from 1 through 14.

- The *first row* of each table contains the names of each measure addressed in the table.
- The *second row* of each table indicates whether the measure is residential, non-residential or both.
- The *third row* of each table lists the median ratio associated with each measure. For Tables M-2 through M-10 and Tables M-20 through M-28, the ratio is the ratio of the incremental savings to the full savings for each measure. For Tables M-11 through M-19, the ratio is the ratio of the incremental costs to the full costs for each measure.

The remaining *cells* in the matrix contain:

- For Tables M-2 through M-10, the cells contain the Inflated Lifecycle Benefit Adjustment Factors
- For Tables M-11 through M-19, the cells contain the Full-Cost Adjustment Factors

4.1.2 Example

Consider the following example for a group of five measures, residential and non-residential air conditioners (central ACs/packaged units) covering four levels of efficiency, each with an EUL of 15 years:

- non-residential domestic electric water heaters (service hot water),
- non-residential domestic gas water heaters,
- non-residential indirect water heaters, and
- non-residential air compressors.

Table M-5 presents the inflated lifecycle benefits adjustment factors for these five measures. For central air conditioners, the program implementer must determine the SEER of the new efficient unit, estimate the RUL for the old unit in place, and select the appropriate lifecycle benefits adjustment factor. For example, if the SEER of the new efficient unit is 17 and the estimated RUL is 4 years, Table M-5 shows that the *inflated lifecycle benefits adjustment factor* is 0.63. Thus, the inflated lifecycle benefits should be multiplied by 0.63.

For a central air conditioner with a SEER of 17 and an estimated RUL of 4 years, Table M-14 shows that the *full-cost adjustment factor* is 0.44. Thus, the full cost of the new efficient central air conditioner should be multiplied by the full-cost adjustment factor of 0.44.

4.1.3 Trends on the Lookup Tables and Calculation of Ratios

This section discusses the directions in which RULs and the savings and costs ratios affect the adjustment factors, and illustrates how the ratios are calculated.

- *Tables M-2 through M-10*: The longer the RUL is, the larger the share of the inflated lifecycle benefits that a PA can claim. Also, the greater the ratio of incremental savings to full savings; the larger the share of the inflated lifecycle benefits that a PA can claim. Consider the following example of equipment with an EUL of 10 years and annual kWh use of 2,000 kWh that is removed in its 6^{th} year (RUL=4 years) and replaced with an energy efficient version of the equipment with an annual kWh use of 1,400 kWh. The full savings are 600 kWh (2,000 - 1,400). It is assumed that in four years the customer would have installed equipment that, at a minimum, met the current efficiency code of annual energy use. The ratio will change depending on the efficiency of the code/standard equipment:

    - If the kWh use associated with code/standard is 1,600 kWh, then the incremental savings = (1,600 – 1,400) or 200 and the ratio = (200/600) or 0.33.

    - If the kWh use associated with code/standard is 1800 kWh, then the incremental savings = (1,800 – 1,400) or 400 and the ratio = (400/600) or 0.67.

A less strict code (one that allows higher consumption) allows a PA to claim a larger share of the inflated lifecycle benefits. In other words, the higher the kWh use associated with the code/standard equipment, the more the program is accomplishing in avoiding standard equipment.

- *Tables M-11 through M-19*: The longer the RUL is, the larger the share of the unadjusted costs for a PA to include (larger time value penalty). Also, the greater the ratio of incremental costs to full costs is, the larger the share of the unadjusted costs for a PA to include. Continuing with the above example, assume that the full cost of the energy efficient equipment is $2,000. It is assumed that in four years the customer would have installed code/standard equipment. The ratio will change depending on the cost of the code/standard equipment:
  - If the full cost of the minimally compliant equipment is $1,400, then the incremental cost = $600 and the ratio = ($600/$2,000) or 0.30.
  - If the full cost of the minimally compliant equipment is $1,800, then the incremental cost = $200 and the ratio = ($200/$2,000) or 0.10.
- The higher cost of the minimally compliant equipment, which lowers the incremental cost, allows a PA to take into account a smaller portion of the full cost of the efficient measure when calculating a TRC. In other words, the higher the cost of the minimally compliant equipment that the customer would have incurred without the program, the lower the cost of the program.

4.2. PA-Based Look-Up Tables

If a PA is able to calculate its own ratio of the incremental savings to full savings and/or the ratio of incremental costs to full cost, then they may choose to use the second set of tables. If a PA chooses to use its own savings ratio and/or cost ratio, it should identify the ratio in the appropriate tables (M-29 through M-47) that is closest to the one(s) it developed. These 19 tables are for the most part organized and interpreted in the same manner as Tables M-2 through M-28. The only exceptions are that the ratios range[799] from 0.95 to .05 in increments of 0.05, and there are no measure designations. To use these tables, a PA will still need to gather the same four pieces of information needed to use the first set of tables:

- the EUL of the new efficient equipment,
- the RUL of the old equipment in place,
- the full savings of the equipment (annual energy use of the old equipment in place minus the annual energy of the high efficiency equipment supported by the program), and
- the full costs (including installation)

Additionally, the PA will need documented estimates of incremental costs and savings in order to calculate:

- The ratio of incremental savings to full savings, and/or
- The ratio of incremental costs to full cost

799 The lookup tables do not apply to measures that have a ratio of *incremental savings to full savings* or a ratio of *incremental costs to full costs* of 1.0 or 0.0 for the same reasons provided earlier in Section 2.1.

Note that all documentation for PA estimates of this data must be retained for Staff review, in accordance with Guidance Document EE-08, dated March 31, 2014. This guidance document can be found at:
www3.dps.ny.gov/W/PSCWeb.nsf/All/31D14D1DDC55FB2185257B240062B398?OpenDocument

Program-Tracking Database Requirements

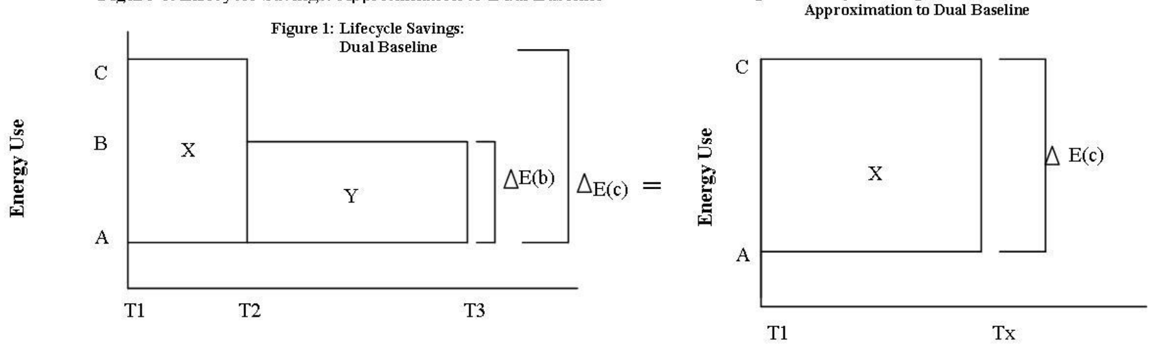
The program tracking databases are maintained by the PAs for the purposes of current reporting and future impact evaluations. The Impact Evaluation section has many fields not used for current reporting. The Department of Public Service hereby adds, for cases of early replacement, six additional required variables.

Type of Installation (TRC Approach)[800] ,

- The *Adjusted Full Savings* (full savings multiplied by the full-savings adjustment factor),
- The *Adjusted Full Cost* (full cost multiplied by the full-cost adjustment factor),
- The Ratio of Incremental Savings to Full Savings,
- The Ratio of Incremental Costs to Full Costs, and
- The *Adjusted EUL* (discussed below)

The Adjusted EUL is defined as that period of years over which the full savings would be claimed such that it matches the present value dollar benefits of the underlying dual baseline. That is, the EUL of the new equipment in Figure 6 below, represented by **Tx – T1**, is adjusted so that the present value of lifecycle benefits represented by area **X** in Figure 6 is equivalent to the present value of the lifecycle benefits represented by the sum of areas **X** and **Y** in Figure 1.

Figure 6. Lifecycle Savings: Approximation to Dual Baseline



The longer the RUL is, the larger the adjusted EUL. This follows the same logic as the case of the *inflated lifecycle benefit adjustment factors* except that the result is an adjusted EUL (that

[800] ER=Early Replacement; NR=Normal Replacement; SC=Special Circumstance; AO=Add On. Add on refers to adding something, which replaces nothing. Examples include adding controls to a boiler that had none, or adding insulation where there was none or some. Add-on measures are modeled at full costs and full savings for the length of their EULs. The full savings are reported toward first-year goals.

portion of the EUL for which the PV of using the full savings would equal the PV of the dual baseline savings).

PAs can obtain the adjusted EULs from the DEER-Based Tables based on typical ratios of incremental savings to full savings or from the PA-Based Tables if a PA can calculate its own savings ratios. The adjusted EUL is not used for TRC screening, but for the program's tracking database. The tables are organized in the same way as the earlier tables. The only difference is that the cells in the matrix contain adjusted EULs in years. Tables M-20 through M-28 contain DEER-Based adjusted EULs while Tables M-39 through M-47 contain PA-Based adjusted EULs.

Table M-2. Inflated Lifecycle Benefit Adjustment Factors: Residential Boilers

	Boiler-G
	Res
	Median Ratio of Incremental Savings to Full Savings
	0.15
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	20%
2	26%
3	32%
4	37%
5	42%
6	47%
7	52%
8	56%
9	60%
10	64%
11	68%
12	68%
13	71%
14	75%
15	78%
16	81%
17	84%
18	86%
19	89%
20	91%
21	94%
22	94%
23	96%
24	98%
EUL =	25

Table M-3. Inflated Lifecycle Benefit Adjustment Factors: Chillers, Furnaces, Non-Res Boilers, and High Performance Windows

	Chiller: Air Cooled Recip and Screw	Chiller: Water Cooled Recip	Chiller: Water Cooled Screw < 150 ton	Chiller: Water Cooled Screw 150-300 ton	Chiller: Water Cooled Screw > 300 ton	Chiller: Water Cooled Centrifugal < 150 ton	Chiller: Water Cooled Centrifugal 150-300 ton	Chiller: Water Cooled Centrifugal > 300 ton	Boiler-G	Furnace-G (AFUE 90)	Furnace-G (AFUE 92)	Furnace-G (AFUE 94)	Furnace-G (AFUE 96)	High Performance Windows-G
	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res
	Median Ratio of Incremental Savings to Full Savings													
	0.50	0.15	0.37	0.31	0.69	0.58	0.38	0.31	0.27	0.44	0.48	0.51	0.54	0.63
RUL	Artificial Lifecycle Benefit Adjustment Factors													
1	53%	23%	42%	36%	72%	63%	42%	36%	35%	47%	53%	53%	58%	68%
2	58%	29%	47%	42%	72%	63%	47%	42%	35%	53%	58%	58%	63%	68%
3	63%	36%	53%	47%	76%	67%	53%	47%	41%	58%	58%	63%	63%	72%
4	63%	42%	58%	53%	76%	72%	58%	53%	47%	63%	63%	68%	68%	72%
5	67%	47%	58%	58%	80%	72%	58%	58%	53%	63%	68%	68%	72%	76%
6	72%	53%	63%	58%	80%	76%	63%	58%	58%	68%	68%	72%	72%	80%
7	72%	53%	67%	63%	84%	76%	67%	63%	63%	72%	72%	76%	76%	80%
8	76%	58%	72%	67%	84%	80%	72%	67%	68%	72%	76%	76%	80%	84%
9	80%	63%	72%	72%	87%	84%	72%	72%	68%	76%	76%	80%	80%	84%
10	80%	67%	76%	76%	87%	84%	76%	76%	72%	80%	80%	80%	84%	87%
11	84%	72%	80%	76%	91%	87%	80%	76%	76%	80%	84%	84%	84%	87%
12	87%	76%	84%	80%	91%	87%	84%	80%	80%	84%	84%	87%	87%	91%
13	87%	80%	84%	84%	94%	91%	84%	84%	84%	87%	87%	87%	87%	91%
14	91%	84%	87%	87%	94%	91%	87%	87%	84%	87%	91%	91%	91%	94%
15	91%	87%	91%	87%	94%	94%	91%	87%	87%	91%	91%	91%	94%	94%
16	94%	91%	91%	91%	97%	94%	91%	91%	91%	94%	94%	94%	94%	94%
17	94%	91%	94%	94%	97%	97%	94%	94%	94%	94%	94%	94%	97%	97%
18	97%	94%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%
19	100%	97%	97%	97%	100%	100%	97%	97%	97%	97%	97%	100%	100%	100%
EUL =	20													

Table M-4. Inflated Lifecycle Benefit Adjustment Factors: Residential Refrigerators

	Refrigerator-E
	Res
	Median Ratio of Incremental Savings to Full Savings
	0.11
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	17%
2	25%
3	32%
4	39%
5	46%
6	52%
7	58%
8	64%
9	69%
10	74%
11	79%
12	79%
13	84%
14	88%
15	92%
16	96%
EUL =	17

Table M-5. Inflated Lifecycle Benefit Adjustment Factors: Central Air Conditioners, Air Source Heat Pumps, Non-Res Water Heaters, Indirect Water Heaters, and Air Compressor Upgrades

	Central Air conditioner (SEER 14)	Central Air conditioner (SEER 15)	Central Air conditioner (SEER 16)	Central Air conditioner (SEER 17)	Central Air conditioner (SEER 18)	DHW-E	DHW-G	Indirect Water Heater-G	Air Compressor Upgrade-E
	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Non-Res	Non-Res	Non-Res	Non-Res
	Median Ratio of Incremental Savings to Full Savings								
	0.19	0.31	0.38	0.44	0.48	0.60	0.21	0.34	0.48
RUL	Artificial Lifecycle Benefit Adjustment Factors								
1	27%	35%	50%	50%	56%	63%	35%	42%	50%
2	35%	43%	50%	56%	56%	69%	35%	49%	56%
3	43%	50%	56%	56%	63%	69%	42%	49%	63%
4	50%	56%	56%	63%	69%	75%	49%	56%	69%
5	56%	63%	63%	69%	69%	75%	56%	63%	69%
6	56%	63%	69%	69%	75%	80%	63%	69%	75%
7	63%	69%	75%	75%	75%	80%	63%	69%	75%
8	69%	75%	75%	80%	80%	86%	69%	75%	80%
9	75%	80%	80%	80%	86%	86%	75%	80%	86%
10	80%	80%	86%	86%	86%	91%	80%	86%	86%
11	86%	86%	86%	91%	91%	91%	86%	86%	91%
12	91%	91%	91%	91%	91%	95%	91%	91%	91%
13	91%	95%	95%	95%	95%	95%	91%	96%	95%
14	95%	95%	95%	95%	95%	100%	96%	96%	95%
EUL =	15								

Table M-6. Inflated Lifecycle Benefit Adjustment Factors: Multi-Family Clothes Washers

RUL	Clothes Washer-G
	MF Res
	Median Ratio of Incremental Savings to Full Savings
	0.39
	Artificial Lifecycle Benefit Adjustment Factors
1	45%
2	52%
3	59%
4	59%
5	66%
6	72%
7	72%
8	78%
9	84%
10	84%
11	90%
12	95%
13	95%
EUL =	14

Table M-7. Inflated Lifecycle Benefit Adjustment Factors: Residential Electric and Indirect Water Heaters

RUL	DHW-E	Indirect Water Heater-G
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.60	0.34
	Artificial Lifecycle Benefit Adjustment Factors	
1	69%	46%
2	69%	46%
3	69%	54%
4	76%	62%
5	76%	62%
6	83%	69%
7	83%	76%
8	89%	82%
9	89%	82%
10	94%	89%
11	94%	94%
12	100%	94%
EUL =	13	

Table M-8. Inflated Lifecycle Benefit Adjustment Factors: Non-Res Refrigerators

	Refrigerator-E
	Non-Res
	Median Ratio of Incremental Savings to Full Savings
	0.34
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	41%
2	50%
3	58%
4	58%
5	66%
6	73%
7	81%
8	81%
9	87%
10	94%
11	94%
EUL =	12

Table M-9. Inflated Lifecycle Benefit Adjustment Factors: Clothes Washers, Dishwashers, and Residential Gas Water Heaters

	Clothes Washer-E	Dishwasher-E	DHW-G
	Res	Res	Res
	Median Ratio of Incremental Savings to Full Savings		
	0.39	0.33	0.21
RUL	Artificial Lifecycle Benefit Adjustment Factors		
1	43%	43%	33%
2	53%	53%	43%
3	62%	53%	43%
4	62%	62%	52%
5	70%	70%	61%
6	78%	78%	70%
7	78%	78%	78%
8	86%	86%	86%
9	93%	93%	86%
10	93%	93%	93%
EUL =	11		

Table M-10. Inflated Lifecycle Benefit Adjustment Factors: Heat Pump Water Heaters and Room A/C

	Heat Pump Water Heater-E	Room Air Conditioner-E
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.87	0.25
RUL	Artificial Lifecycle Benefit Adjustment Factors	
1	92%	36%
2	92%	47%
3	92%	57%
4	92%	57%
5	92%	66%
6	92%	75%
7	100%	84%
8	100%	84%
9	100%	92%
EUL =	10	

Table M-11. Full-Cost Adjustment Factors: Residential Boilers

	Boiler-G
	Res
	Median Ratio of Incremental Cost to Full Cost
	0.16
RUL	Full Cost Adjustment Factors
1	20%
2	25%
3	28%
4	32%
5	36%
6	39%
7	42%
8	45%
9	48%
10	51%
11	53%
12	56%
13	58%
14	60%
15	62%
16	64%
17	66%
18	68%
19	70%
20	71%
21	73%
22	74%
23	75%
24	77%
EUL =	25

Table M-12. Full-Cost Adjustment Factors: Chillers, Furnaces, Non-Res Boilers, and High Performance Windows

RUL	Chiller: Air Cooled Recip and Screw	Chiller: Water Cooled Recip	Chiller: Water Cooled Screw < 150 ton	Chiller: Water Cooled Screw 150-300 ton	Chiller: Water Cooled Screw > 300 ton	Chiller: Water Cooled Centrifugal < 150 ton	Chiller: Water Cooled Centrifugal 150-300 ton	Chiller: Water Cooled Centrifugal > 300 ton	Boiler-G	Furnace-G (AFUE 90)	Furnace-G (AFUE 92)	Furnace-G (AFUE 94)	Furnace-G (AFUE 96)	High Performance Windows-G
	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res
	Median Ratio of Incremental Cost to Full Cost													
	0.18	0.03	0.16	0.13	0.12	0.21	0.24	0.33	0.48	0.28	0.31	0.34	0.36	0.10
	Full Cost Adjustment Factors													
1	22%	8%	20%	18%	17%	25%	28%	36%	51%	32%	35%	37%	39%	15%
2	26%	13%	25%	22%	21%	29%	32%	40%	53%	35%	38%	41%	42%	19%
3	30%	17%	28%	26%	25%	33%	35%	43%	56%	39%	41%	44%	45%	23%
4	34%	22%	32%	30%	29%	36%	39%	46%	58%	42%	44%	47%	48%	27%
5	37%	26%	36%	33%	33%	40%	42%	49%	60%	45%	47%	50%	51%	31%
6	41%	30%	39%	37%	36%	43%	45%	51%	62%	48%	50%	52%	54%	35%
7	44%	33%	42%	40%	40%	46%	48%	54%	64%	51%	53%	55%	56%	38%
8	47%	37%	45%	43%	43%	49%	50%	56%	66%	53%	55%	57%	58%	41%
9	49%	40%	48%	46%	46%	51%	53%	59%	68%	56%	57%	59%	60%	44%
10	52%	43%	51%	49%	48%	54%	56%	61%	70%	58%	60%	61%	63%	47%
11	54%	46%	53%	52%	51%	56%	58%	63%	71%	60%	62%	63%	64%	50%
12	57%	49%	56%	54%	54%	58%	60%	65%	73%	62%	64%	65%	66%	53%
13	59%	52%	58%	57%	56%	61%	62%	67%	74%	64%	66%	67%	68%	55%
14	61%	54%	60%	59%	58%	63%	64%	68%	75%	66%	67%	69%	70%	57%
15	63%	57%	62%	61%	61%	65%	66%	70%	77%	68%	69%	70%	71%	60%
16	65%	59%	64%	63%	63%	66%	68%	72%	78%	69%	71%	72%	73%	62%
17	67%	61%	66%	65%	65%	68%	69%	73%	79%	71%	72%	73%	74%	64%
18	69%	63%	68%	67%	66%	70%	71%	74%	80%	73%	74%	75%	76%	66%
19	70%	65%	70%	69%	68%	71%	73%	76%	81%	74%	75%	76%	77%	67%
EUL =	20													

Table M-13. Full-Cost Adjustment Factors: Residential Refrigerators

	Refrigerator-E
	Res
	Median Ratio of Incremental Cost to Full Cost
	0.12
RUL	Full Cost Adjustment Factors
1	17%
2	21%
3	25%
4	29%
5	33%
6	36%
7	40%
8	43%
9	46%
10	48%
11	51%
12	54%
13	56%
14	58%
15	61%
16	63%
EUL =	17

Table M-14. Full-Cost Adjustment Factors: Central Air Conditioners, Air Source Heat Pumps, Non-Res Water Heaters, Indirect Water Heaters, and Air Compressor Upgrades

RUL	Central Air Conditioner/Air Source Heat Pumps (SEER 14)	Central Air Conditioner/Air Source Heat Pumps (SEER 15)	Central Air Conditioner/Air Source Heat Pumps (SEER 16)	Central Air Conditioner/Air Source Heat Pumps (SEER 17)	Central Air Conditioner/Air Source Heat Pumps (SEER 18)	DHW-E	DHW-G	Indirect Water Heater-G	Air Compressor Upgrade-E
	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Non-Res	Non-Res	Non-Res	Non-Res
	Median Ratio of Incremental Cost to Full Cost								
	0.10	0.20	0.26	0.31	0.37	0.25	0.22	0.93	0.46
	Full Cost Adjustment Factors								
1	15%	24%	30%	35%	40%	29%	26%	93%	49%
2	19%	28%	34%	38%	43%	33%	30%	94%	51%
3	23%	32%	37%	41%	46%	36%	34%	94%	54%
4	27%	35%	40%	44%	49%	39%	37%	94%	56%
5	31%	39%	43%	47%	52%	43%	40%	95%	59%
6	35%	42%	46%	50%	54%	46%	43%	95%	61%
7	38%	45%	49%	53%	57%	48%	46%	95%	63%
8	41%	48%	52%	55%	59%	51%	49%	95%	65%
9	44%	51%	54%	57%	61%	54%	52%	96%	67%
10	47%	53%	57%	60%	63%	56%	54%	96%	68%
11	50%	56%	59%	62%	65%	58%	57%	96%	70%
12	53%	58%	61%	64%	67%	61%	59%	96%	72%
13	55%	60%	63%	66%	69%	63%	61%	97%	73%
14	57%	62%	65%	67%	70%	65%	63%	97%	74%
EUL =	15								

Table M-15. Full-Cost Adjustment Factors: Multi-Family Clothes Washers

	Clothes Washer-G
	MF Res
	Median Ratio of Incremental Cost to Full Cost
	0.24
RUL	Full Cost Adjustment Factors
1	28%
2	32%
3	35%
4	39%
5	42%
6	45%
7	48%
8	50%
9	53%
10	56%
11	58%
12	60%
13	62%
EUL =	14

Table M-16. Full-Cost Adjustment Factors: Residential Electric and Indirect Water Heaters

RUL	DHW-E	Indirect Water Heater-G
	Res	Res
	Median Ratio of Incremental Cost to Full Cost	
	0.25	0.93
	Full Cost Adjustment Factors	
1	29%	93%
2	33%	94%
3	36%	94%
4	39%	94%
5	43%	95%
6	46%	95%
7	48%	95%
8	51%	95%
9	54%	96%
10	56%	96%
11	58%	96%
12	61%	96%
EUL =	13	

Table M-17. Full-Cost Adjustment Factors: Non-Residential Refrigerators

RUL	Refrigerator-E
	Non-Res
	Median Ratio of Incremental Cost to Full Cost
	0.05
	Full Cost Adjustment Factors
1	10%
2	15%
3	19%
4	23%
5	27%
6	31%
7	35%
8	38%
9	41%
10	44%
11	47%
EUL =	12

Table M-18. Full-Cost Adjustment Factors: Clothes Washers, Dishwashers, and Residential Gas Water Heaters

RUL	Clothes Washer-E	Dishwasher-E	DHW-G
	Res	Res	Res
	Median Ratio of Incremental Cost to Full Cost		
	0.24	0.06	0.22
	Full Cost Adjustment Factors		
1	28%	11%	26%
2	32%	16%	30%
3	35%	20%	34%
4	39%	24%	37%
5	42%	28%	40%
6	45%	32%	43%
7	48%	35%	46%
8	50%	39%	49%
9	53%	42%	52%
10	56%	45%	54%
EUL =	11		

Table M-19. Full-Cost Adjustment Factors: Heat Pump Water Heaters and Room A/C

RUL	Heat Pump Water Heater-E	Room Air Conditioner-E
	Res	Res
	Median Ratio of Incremental Cost to Full Cost	
	0.77	0.23
	Full Cost Adjustment Factors	
1	78%	27%
2	79%	31%
3	80%	34%
4	81%	38%
5	82%	41%
6	83%	44%
7	84%	47%
8	85%	50%
9	86%	52%
EUL =	10	

Table M-20. Adjusted EULs: Residential Boilers

	Boiler-G
	Res
	Median Ratio of Incremental Savings to Full Savings
	0.15
RUL	Adjusted EULs in Years
1	3
2	4
3	5
4	6
5	7
6	8
7	9
8	10
9	11
10	12
11	13
12	13
13	14
14	15
15	16
16	17
17	18
18	19
19	20
20	21
21	22
22	22
23	23
24	24
EUL =	25

Table M -21. Adjusted EULs: Chillers, Furnaces, Non-Residential Boilers, and High Performance Windows

RUL	Chiller: Air Cooled Recip and Screw	Chiller: Water Cooled Recip	Chiller: Water Cooled Screw < 150 ton	Chiller: Water Cooled Screw 150-300 ton	Chiller: Water Cooled Screw > 300 ton	Chiller: Water Cooled Centrifugal < 150 ton	Chiller: Water Cooled Centrifugal 150-300 ton	Chiller: Water Cooled Centrifugal > 300 ton	Boiler-G	Furnace-G (AFUE 90)	Furnace-G (AFUE 92)	Furnace-G (AFUE 94)	Furnace-G (AFUE 96)	High Performance Windows-G
	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res
	Median Ratio of Incremental Savings to Full Savings													
	0.50	0.15	0.37	0.31	0.69	0.58	0.38	0.31	0.27	0.44	0.48	0.51	0.54	0.63
	Adjusted EULs in Years													
1	8	3	6	5	12	10	6	5	5	7	8	8	9	11
2	9	4	7	6	12	10	7	6	5	8	9	9	10	11
3	10	5	8	7	13	11	8	7	6	9	9	10	10	12
4	10	6	9	8	13	12	9	8	7	10	10	11	11	12
5	11	7	9	9	14	12	9	9	8	10	11	11	12	13
6	12	8	10	9	14	13	10	9	9	11	11	12	12	14
7	12	8	11	10	15	13	11	10	10	12	12	13	13	14
8	13	9	12	11	15	14	12	11	11	12	13	13	14	15
9	14	10	12	12	16	15	12	12	11	13	13	14	14	15
10	14	11	13	13	16	15	13	13	12	14	14	14	15	16
11	15	12	14	13	17	16	14	13	13	14	15	15	15	16
12	16	13	15	14	17	16	15	14	14	15	15	16	16	17
13	16	14	15	15	18	17	15	15	15	16	16	16	16	17
14	17	15	16	16	18	17	16	16	15	16	17	17	17	18
15	17	16	17	16	18	18	17	16	16	17	17	17	18	18
16	18	17	17	17	19	18	17	17	17	18	18	18	18	18
17	18	17	18	18	19	19	18	18	18	18	18	18	19	19
18	19	18	19	19	19	19	19	19	19	19	19	19	19	19
19	20	19	19	19	20	20	19	19	19	19	19	20	20	20
EUL =	20													

Table M-22. Adjusted EULs: Residential Refrigerators

RUL	Refrigerator-E Res Median Ratio of Incremental Savings to Full Savings 0.11 Adjusted EULs in Years
1	2
2	3
3	4
4	5
5	6
6	7
7	8
8	9
9	10
10	11
11	12
12	12
13	13
14	14
15	15
16	16
EUL =	17

Table M-23. Adjusted EULs: Central Air Conditioners, Air Source Heat Pumps, Non-Res Water Heaters, Indirect Water Heaters, and Air Compressor Upgrades

	Central Air Conditioner/Air Source Heat Pumps (SEER 14)	Central Air Conditioner/Air Source Heat Pumps (SEER 15)	Central Air Conditioner/Air Source Heat Pumps (SEER 16)	Central Air Conditioner/Air Source Heat Pumps (SEER 17)	Central Air Conditioner/Air Source Heat Pumps (SEER 18)	DHW-E	DHW-G	Indirect Water Heater-G	Air Compressor Upgrade-E
	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Non-Res	Non-Res	Non-Res	Non-Res
	Median Ratio of Incremental Savings to Full Savings								
	0.19	0.31	0.38	0.44	0.48	0.60	0.21	0.34	0.48
RUL	Adjusted EULs in Years								
1	3	4	6	6	7	8	4	5	6
2	4	5	6	7	7	9	4	6	7
3	5	6	7	7	8	9	5	6	8
4	6	7	7	8	9	10	6	7	9
5	7	8	8	9	9	10	7	8	9
6	7	8	9	9	10	11	8	9	10
7	8	9	10	10	10	11	8	9	10
8	9	10	10	11	11	12	9	10	11
9	10	11	11	11	12	12	10	11	12
10	11	11	12	12	12	13	11	12	12
11	12	12	12	13	13	13	12	12	13
12	13	13	13	13	13	14	13	13	13
13	13	14	14	14	14	14	13	14	14
14	14	14	14	14	14	15	14	14	14
EUL =	15								

TABLE M-24. ADJUSTED EULS: MULTI-FAMILY CLOTHES WASHERS

	Clothes Washer-G
	MF Res
	Median Ratio of Incremental Savings to Full Savings
	0.39
RUL	Adjusted EULs in Years
1	5
2	6
3	7
4	7
5	8
6	9
7	9
8	10
9	11
10	11
11	12
12	13
13	13
EUL =	14

TABLE M-25. ADJUSTED EULS: RESIDENTIAL ELECTRIC AND GAS INDIRECT WATER HEATERS

	DHW-E	Indirect Water Heater-G
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.60	0.34
RUL	Adjusted EULs in Years	
1	8	5
2	8	5
3	8	6
4	9	7
5	9	7
6	10	8
7	10	9
8	11	10
9	11	10
10	12	11
11	12	12
12	13	12
EUL =	13	

TABLE M-26. ADJUSTED EULS: NON-RESIDENTIAL REFRIGERATORS

RUL	Refrigerator-E Non-Res Median Ratio of Incremental Savings to Full Savings 0.34 Adjusted EULs in Years
1	4
2	5
3	6
4	6
5	7
6	8
7	9
8	9
9	10
10	11
11	11
EUL =	12

Table M-27. Adjusted EULs: Clothes Washers, Dishwashers, and Residential Gas Water Heaters

	Clothes Washer-E	Dishwasher-E	DHW-G
	Res	Res	Res
	Median Ratio of Incremental Savings to Full Savings		
	0.39	0.33	0.21
RUL	Adjusted EULs in Years		
1	4	4	3
2	5	5	4
3	6	5	4
4	6	6	5
5	7	7	6
6	8	8	7
7	8	8	8
8	9	9	9
9	10	10	9
10	10	10	10
EUL =	11		

Table M-28. Adjusted EULs: Heat Pump Water Heaters and Room A/C

	Heat Pump Water Heater-E	Room Air Conditioner-E
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.87	0.25
RUL	Adjusted EULs in Years	
1	9	3
2	9	4
3	9	5
4	9	5
5	9	6
6	9	7
7	10	8
8	10	8
9	10	9
EUL =	10	

Table M-29. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 25 Year EUL

	Savings																		
RU	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9
1	14	14	20	26	32	37	42	42	47	52	60	64	68	71	78	81	86	91	96
2	20	20	26	32	37	42	42	47	52	56	60	64	71	75	78	84	86	91	96
3	26	26	32	37	42	42	47	52	56	60	64	68	71	75	81	84	89	91	96
4	32	32	37	42	47	47	52	56	60	64	68	71	75	78	81	86	89	94	96
5	37	37	42	47	47	52	56	60	64	68	68	71	75	81	84	86	89	94	96
6	42	42	47	52	52	56	60	64	64	68	71	75	78	81	84	86	91	94	96
7	47	47	52	52	56	60	64	64	68	71	75	78	81	84	86	89	91	94	98
8	52	52	56	56	60	64	64	68	71	75	75	78	81	84	86	89	91	94	98
9	56	56	60	60	64	68	68	71	75	75	78	81	84	86	89	91	94	96	98
1	60	60	64	64	68	68	71	75	75	78	81	84	84	86	89	91	94	96	98
1	64	64	68	68	71	71	75	75	78	81	81	84	86	89	89	91	94	96	98
1	64	68	68	71	75	75	78	78	81	81	84	86	86	89	91	94	94	96	98
1	68	71	71	75	75	78	78	81	81	84	86	86	89	91	91	94	96	96	98
1	71	75	75	78	78	81	81	84	84	86	86	89	89	91	94	94	96	98	98
1	75	78	78	81	81	81	84	84	86	86	89	89	91	91	94	96	96	98	98
1	78	81	81	81	84	84	86	86	89	89	89	91	91	94	94	96	96	98	98
1	81	84	84	84	86	86	86	89	89	91	91	91	94	94	96	96	98	98	100
1	84	86	86	86	89	89	89	91	91	91	94	94	94	96	96	96	98	98	100
1	86	89	89	89	89	91	91	91	91	94	94	94	96	96	96	98	98	98	100
2	89	89	91	91	91	91	94	94	94	94	96	96	96	96	98	98	98	98	100
2	91	91	94	94	94	94	94	96	96	96	96	96	98	98	98	98	98	100	100
2	94	94	94	96	96	96	96	96	96	96	98	98	98	98	98	98	100	100	100
2	96	96	96	96	96	98	98	98	98	98	98	98	98	98	98	100	100	100	100
2	98	98	98	98	98	98	98	98	98	100	100	100	100	100	100	100	100	100	100
EUL	2																		

Table M-30. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 20 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	16%	16%	23%	29%	29%	36%	42%	47%	47%	53%	58%	63%	67%	72%	76%	80%	87%	91%	94%
2	23%	23%	29%	29%	36%	42%	47%	47%	53%	58%	63%	67%	72%	76%	80%	84%	87%	91%	97%
3	29%	29%	36%	36%	42%	47%	47%	53%	58%	63%	67%	67%	72%	76%	80%	84%	87%	91%	97%
4	36%	36%	42%	42%	47%	53%	53%	58%	63%	63%	67%	72%	76%	80%	84%	87%	91%	94%	97%
5	42%	42%	47%	47%	53%	53%	58%	63%	63%	67%	72%	76%	76%	80%	84%	87%	91%	94%	97%
6	47%	47%	53%	53%	58%	58%	63%	63%	67%	72%	72%	76%	80%	84%	84%	87%	91%	94%	97%
7	47%	53%	53%	58%	63%	63%	67%	67%	72%	72%	76%	80%	80%	84%	87%	91%	91%	94%	97%
8	53%	58%	58%	63%	63%	67%	67%	72%	76%	76%	80%	80%	84%	87%	87%	91%	94%	94%	97%
9	58%	63%	63%	67%	67%	72%	72%	76%	76%	80%	80%	84%	84%	87%	91%	91%	94%	97%	97%
10	63%	67%	67%	72%	72%	72%	76%	76%	80%	80%	84%	84%	87%	87%	91%	94%	94%	97%	97%
11	67%	72%	72%	72%	76%	76%	80%	80%	84%	84%	84%	87%	87%	91%	91%	94%	94%	97%	97%
12	72%	76%	76%	76%	80%	80%	80%	84%	84%	87%	87%	87%	91%	91%	94%	94%	97%	97%	100%
13	76%	80%	80%	80%	84%	84%	84%	87%	87%	87%	91%	91%	91%	94%	94%	94%	97%	97%	100%
14	80%	84%	84%	84%	84%	87%	87%	87%	87%	91%	91%	91%	94%	94%	94%	97%	97%	97%	100%
15	84%	84%	87%	87%	87%	87%	91%	91%	91%	91%	94%	94%	94%	94%	97%	97%	97%	97%	100%
16	87%	87%	91%	91%	91%	91%	91%	94%	94%	94%	94%	94%	97%	97%	97%	97%	97%	100%	100%
17	91%	91%	91%	94%	94%	94%	94%	94%	94%	94%	97%	97%	97%	97%	97%	97%	100%	100%	100%
18	94%	94%	94%	94%	94%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	100%	100%	100%	100%
19	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	20																		

Table M-31. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 17 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	17%	17%	25%	25%	32%	39%	39%	46%	52%	52%	58%	64%	69%	74%	79%	84%	88%	92%	96%
2	25%	25%	32%	32%	39%	39%	46%	52%	52%	58%	64%	69%	69%	74%	79%	84%	88%	92%	96%
3	32%	32%	39%	39%	46%	46%	52%	52%	58%	64%	64%	69%	74%	79%	79%	84%	88%	92%	96%
4	32%	39%	39%	46%	52%	52%	58%	58%	64%	64%	69%	74%	74%	79%	84%	88%	88%	92%	96%
5	39%	46%	46%	52%	52%	58%	58%	64%	69%	69%	74%	74%	79%	84%	84%	88%	92%	92%	96%
6	46%	52%	52%	58%	58%	64%	64%	69%	69%	74%	74%	79%	79%	84%	88%	88%	92%	96%	96%
7	52%	58%	58%	64%	64%	69%	69%	69%	74%	74%	79%	79%	84%	84%	88%	92%	92%	96%	96%
8	58%	64%	64%	69%	69%	69%	74%	74%	79%	79%	79%	84%	84%	88%	88%	92%	92%	96%	96%
9	64%	69%	69%	69%	74%	74%	74%	79%	79%	84%	84%	84%	88%	88%	92%	92%	96%	96%	100%
10	69%	74%	74%	74%	79%	79%	79%	84%	84%	84%	88%	88%	88%	92%	92%	92%	96%	96%	100%
11	74%	79%	79%	79%	79%	84%	84%	84%	84%	88%	88%	88%	92%	92%	92%	96%	96%	96%	100%
12	79%	79%	84%	84%	84%	84%	88%	88%	88%	88%	92%	92%	92%	92%	96%	96%	96%	96%	100%
13	84%	84%	88%	88%	88%	88%	88%	92%	92%	92%	92%	92%	96%	96%	96%	96%	96%	100%	100%
14	88%	88%	88%	92%	92%	92%	92%	92%	92%	92%	96%	96%	96%	96%	96%	96%	100%	100%	100%
15	92%	92%	92%	92%	92%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	100%	100%	100%	100%
16	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	17																		

Table M-32. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 15 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	19%	19%	27%	27%	35%	35%	43%	43%	50%	56%	56%	63%	69%	75%	75%	80%	86%	91%	95%
2	19%	27%	27%	35%	43%	43%	50%	50%	56%	56%	63%	69%	69%	75%	80%	86%	86%	91%	95%
3	27%	35%	35%	43%	43%	50%	50%	56%	63%	63%	69%	69%	75%	80%	80%	86%	91%	91%	95%
4	35%	43%	43%	50%	50%	56%	56%	63%	63%	69%	69%	75%	75%	80%	86%	86%	91%	95%	95%
5	43%	50%	50%	56%	56%	63%	63%	63%	69%	69%	75%	75%	80%	80%	86%	91%	91%	95%	95%
6	50%	56%	56%	63%	63%	63%	69%	69%	75%	75%	75%	80%	80%	86%	86%	91%	91%	95%	95%
7	56%	63%	63%	63%	69%	69%	69%	75%	75%	80%	80%	80%	86%	86%	91%	91%	95%	95%	100%
8	63%	69%	69%	69%	75%	75%	75%	80%	80%	80%	86%	86%	86%	91%	91%	91%	95%	95%	100%
9	69%	75%	75%	75%	75%	80%	80%	80%	80%	86%	86%	86%	91%	91%	91%	95%	95%	95%	100%
10	75%	75%	80%	80%	80%	80%	86%	86%	86%	86%	91%	91%	91%	91%	95%	95%	95%	95%	100%
11	80%	80%	86%	86%	86%	86%	86%	91%	91%	91%	91%	91%	95%	95%	95%	95%	95%	100%	100%
12	86%	86%	86%	91%	91%	91%	91%	91%	91%	91%	95%	95%	95%	95%	95%	95%	100%	100%	100%
13	91%	91%	91%	91%	91%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%
14	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	15																		

Table M-33. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 14 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	10%	19%	19%	28%	37%	37%	45%	45%	52%	52%	59%	66%	66%	72%	78%	84%	84%	90%	95%
2	19%	28%	28%	37%	37%	45%	45%	52%	59%	59%	66%	66%	72%	78%	78%	84%	90%	90%	95%
3	28%	37%	37%	45%	45%	52%	52%	59%	59%	66%	66%	72%	72%	78%	84%	84%	90%	95%	95%
4	37%	45%	45%	52%	52%	59%	59%	59%	66%	66%	72%	72%	78%	78%	84%	90%	90%	95%	95%
5	45%	52%	52%	59%	59%	59%	66%	66%	72%	72%	72%	78%	78%	84%	84%	90%	90%	95%	95%
6	52%	59%	59%	59%	66%	66%	66%	72%	72%	78%	78%	78%	84%	84%	90%	90%	95%	95%	100%
7	59%	66%	66%	66%	72%	72%	72%	78%	78%	78%	84%	84%	84%	90%	90%	90%	95%	95%	100%
8	66%	72%	72%	72%	72%	78%	78%	78%	78%	84%	84%	84%	90%	90%	90%	95%	95%	95%	100%
9	72%	72%	78%	78%	78%	78%	84%	84%	84%	84%	90%	90%	90%	90%	95%	95%	95%	95%	100%
10	78%	78%	84%	84%	84%	84%	84%	90%	90%	90%	90%	90%	95%	95%	95%	95%	95%	100%	100%
11	84%	84%	84%	90%	90%	90%	90%	90%	90%	90%	95%	95%	95%	95%	95%	95%	100%	100%	100%
12	90%	90%	90%	90%	90%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%
13	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	14																		

Table M-34. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 13 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	11%	20%	20%	30%	30%	39%	39%	47%	55%	55%	62%	62%	69%	76%	76%	83%	89%	89%	94%
2	20%	30%	30%	39%	39%	47%	47%	55%	55%	62%	62%	69%	69%	76%	83%	83%	89%	94%	94%
3	30%	39%	39%	47%	47%	55%	55%	55%	62%	62%	69%	69%	76%	76%	83%	89%	89%	94%	94%
4	39%	47%	47%	55%	55%	55%	62%	62%	69%	69%	69%	76%	76%	83%	83%	89%	89%	94%	94%
5	47%	55%	55%	55%	62%	62%	62%	69%	69%	76%	76%	76%	83%	83%	89%	89%	94%	94%	100%
6	55%	62%	62%	62%	69%	69%	69%	76%	76%	76%	83%	83%	83%	89%	89%	89%	94%	94%	100%
7	62%	69%	69%	69%	69%	76%	76%	76%	76%	83%	83%	83%	89%	89%	89%	94%	94%	94%	100%
8	69%	69%	76%	76%	76%	76%	83%	83%	83%	83%	89%	89%	89%	89%	94%	94%	94%	94%	100%
9	76%	76%	83%	83%	83%	83%	83%	89%	89%	89%	89%	89%	94%	94%	94%	94%	94%	100%	100%
10	83%	83%	83%	89%	89%	89%	89%	89%	89%	89%	94%	94%	94%	94%	94%	94%	100%	100%	100%
11	89%	89%	89%	89%	89%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%
12	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	13																		

Table M-35. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 12 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	11%	22%	22%	32%	32%	41%	41%	50%	50%	58%	58%	66%	66%	73%	81%	81%	87%	94%	94%
2	22%	32%	32%	41%	41%	41%	50%	50%	58%	58%	66%	66%	73%	73%	81%	87%	87%	94%	94%
3	32%	41%	41%	41%	50%	50%	58%	58%	66%	66%	66%	73%	73%	81%	81%	87%	87%	94%	94%
4	41%	50%	50%	50%	58%	58%	58%	66%	66%	73%	73%	73%	81%	81%	87%	87%	94%	94%	100%
5	50%	58%	58%	58%	66%	66%	66%	73%	73%	73%	81%	81%	81%	87%	87%	87%	94%	94%	100%
6	58%	66%	66%	66%	66%	73%	73%	73%	73%	81%	81%	81%	87%	87%	87%	94%	94%	94%	100%
7	66%	66%	73%	73%	73%	73%	81%	81%	81%	81%	87%	87%	87%	87%	94%	94%	94%	94%	100%
8	73%	73%	81%	81%	81%	81%	81%	87%	87%	87%	87%	87%	94%	94%	94%	94%	94%	100%	100%
9	81%	81%	81%	87%	87%	87%	87%	87%	87%	87%	94%	94%	94%	94%	94%	94%	100%	100%	100%
10	87%	87%	87%	87%	87%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%
11	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	12																		

Table M-36. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for an 11 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	12%	23%	23%	34%	34%	34%	43%	43%	53%	53%	62%	62%	70%	70%	78%	86%	86%	93%	93%
2	23%	34%	34%	34%	43%	43%	53%	53%	62%	62%	62%	70%	70%	78%	78%	86%	86%	93%	93%
3	34%	43%	43%	43%	53%	53%	53%	62%	62%	70%	70%	70%	78%	78%	86%	86%	93%	93%	100%
4	43%	53%	53%	53%	62%	62%	62%	70%	70%	70%	78%	78%	78%	86%	86%	86%	93%	93%	100%
5	53%	62%	62%	62%	62%	70%	70%	70%	70%	78%	78%	78%	86%	86%	86%	93%	93%	93%	100%
6	62%	62%	70%	70%	70%	70%	78%	78%	78%	78%	86%	86%	86%	86%	93%	93%	93%	93%	100%
7	70%	70%	78%	78%	78%	78%	78%	86%	86%	86%	86%	86%	93%	93%	93%	93%	93%	100%	100%
8	78%	78%	78%	86%	86%	86%	86%	86%	86%	86%	93%	93%	93%	93%	93%	93%	100%	100%	100%
9	86%	86%	86%	86%	86%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	100%	100%	100%	100%
10	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	11																		

Table M-37. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 10 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	13%	25%	25%	25%	36%	36%	47%	47%	57%	57%	57%	66%	66%	75%	75%	84%	84%	92%	92%
2	25%	36%	36%	36%	47%	47%	47%	57%	57%	66%	66%	66%	75%	75%	84%	84%	92%	92%	100%
3	36%	47%	47%	47%	57%	57%	57%	66%	66%	66%	75%	75%	75%	84%	84%	84%	92%	92%	100%
4	47%	57%	57%	57%	57%	66%	66%	66%	66%	75%	75%	75%	84%	84%	84%	92%	92%	92%	100%
5	57%	57%	66%	66%	66%	66%	75%	75%	75%	75%	84%	84%	84%	84%	92%	92%	92%	92%	100%
6	66%	66%	75%	75%	75%	75%	75%	84%	84%	84%	84%	84%	92%	92%	92%	92%	92%	100%	100%
7	75%	75%	75%	84%	84%	84%	84%	84%	84%	84%	92%	92%	92%	92%	92%	92%	100%	100%	100%
8	84%	84%	84%	84%	84%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	100%	100%	100%	100%
9	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	10																		

Table M-38. Full Cost Adjustment Factors

	Cost Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	10%	15%	19%	24%	29%	34%	38%	43%	48%	53%	57%	62%	67%	72%	76%	81%	86%	91%	95%
2	15%	19%	24%	28%	33%	37%	42%	46%	51%	55%	60%	64%	69%	73%	78%	82%	87%	91%	96%
3	19%	23%	28%	32%	36%	40%	45%	49%	53%	57%	62%	66%	70%	74%	79%	83%	87%	91%	96%
4	23%	27%	31%	35%	39%	43%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%
5	27%	31%	35%	39%	43%	46%	50%	54%	58%	62%	66%	69%	73%	77%	81%	85%	89%	92%	96%
6	31%	35%	38%	42%	46%	49%	53%	56%	60%	64%	67%	71%	75%	78%	82%	85%	89%	93%	96%
7	35%	38%	42%	45%	48%	52%	55%	59%	62%	66%	69%	73%	76%	79%	83%	86%	90%	93%	97%
8	38%	41%	45%	48%	51%	54%	58%	61%	64%	67%	71%	74%	77%	80%	84%	87%	90%	93%	97%
9	41%	44%	48%	51%	54%	57%	60%	63%	66%	69%	72%	75%	78%	81%	85%	88%	91%	94%	97%
10	44%	47%	50%	53%	56%	59%	62%	65%	68%	71%	74%	77%	80%	82%	85%	88%	91%	94%	97%
11	47%	50%	53%	56%	58%	61%	64%	67%	69%	72%	75%	78%	81%	83%	86%	89%	92%	94%	97%
12	50%	53%	55%	58%	61%	63%	66%	68%	71%	74%	76%	79%	82%	84%	87%	89%	92%	95%	97%
13	53%	55%	58%	60%	63%	65%	68%	70%	73%	75%	78%	80%	83%	85%	88%	90%	93%	95%	98%
14	55%	57%	60%	62%	65%	67%	69%	72%	74%	76%	79%	81%	83%	86%	88%	91%	93%	95%	98%
15	57%	60%	62%	64%	66%	69%	71%	73%	75%	78%	80%	82%	84%	87%	89%	91%	93%	96%	98%
16	60%	62%	64%	66%	68%	70%	72%	75%	77%	79%	81%	83%	85%	87%	89%	92%	94%	96%	98%
17	62%	64%	66%	68%	70%	72%	74%	76%	78%	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%
18	64%	66%	68%	69%	71%	73%	75%	77%	79%	81%	83%	85%	87%	89%	90%	92%	94%	96%	98%
19	66%	67%	69%	71%	73%	75%	76%	78%	80%	82%	84%	86%	87%	89%	91%	93%	95%	96%	98%
20	67%	69%	71%	73%	74%	76%	78%	79%	81%	83%	85%	86%	88%	90%	91%	93%	95%	97%	98%
21	69%	71%	72%	74%	76%	77%	79%	81%	82%	84%	85%	87%	89%	90%	92%	94%	95%	97%	98%
22	71%	72%	74%	75%	77%	78%	80%	82%	83%	85%	86%	88%	89%	91%	92%	94%	95%	97%	98%
23	72%	74%	75%	77%	78%	80%	81%	82%	84%	85%	87%	88%	90%	91%	93%	94%	96%	97%	99%
24	74%	75%	76%	78%	79%	81%	82%	83%	85%	86%	88%	89%	90%	92%	93%	94%	96%	97%	99%
EUL =	25																		

Table M-39. Adjusted EULs for a 25 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	2	2	3	4	5	6	7	7	8	9	11	12	13	14	16	17	19	21	23
2	3	3	4	5	6	7	7	8	9	10	11	12	14	15	16	18	19	21	23
3	4	4	5	6	7	7	8	9	10	11	12	13	14	15	17	18	20	21	23
4	5	5	6	7	8	8	9	10	11	12	13	14	15	16	17	19	20	22	23
5	6	6	7	8	8	9	10	11	12	13	13	14	15	17	18	19	20	22	23
6	7	7	8	9	9	10	11	12	12	13	14	15	16	17	18	19	21	22	23
7	8	8	9	9	10	11	12	12	13	14	15	16	17	18	19	20	21	22	24
8	9	9	10	10	11	12	12	13	14	15	15	16	17	18	19	20	21	22	24
9	10	10	11	11	12	13	13	14	15	15	16	17	18	19	20	21	22	23	24
10	11	11	12	12	13	13	14	15	15	16	17	18	18	19	20	21	22	23	24
11	12	12	13	13	14	14	15	15	16	17	17	18	19	20	20	21	22	23	24
12	12	13	13	14	15	15	16	16	17	17	18	19	19	20	21	22	22	23	24
13	13	14	14	15	15	16	16	17	17	18	19	19	20	21	21	22	23	23	24
14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	22	22	23	24	24
15	15	16	16	17	17	17	18	18	19	19	20	20	21	21	22	23	23	24	24
16	16	17	17	17	18	18	19	19	20	20	20	21	21	22	22	23	23	24	24
17	17	18	18	18	19	19	19	20	20	21	21	21	22	22	23	23	24	24	25
18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24	24	25
19	19	20	20	20	20	21	21	21	21	22	22	22	23	23	23	24	24	24	25
20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25
21	21	21	22	22	22	22	22	23	23	23	23	23	24	24	24	24	24	25	25
22	22	22	22	23	23	23	23	23	23	23	24	24	24	24	24	24	25	25	25
23	23	23	23	23	23	24	24	24	24	24	24	24	24	24	24	25	25	25	25
24	24	24	24	24	24	24	24	24	24	25	25	25	25	25	25	25	25	25	25
EUL =	**25**																		

Table M-40. Adjusted EULs for a 20 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	2	2	3	4	4	5	6	7	7	8	9	10	11	12	13	14	16	17	18
2	3	3	4	4	5	6	7	7	8	9	10	11	12	13	14	15	16	17	19
3	4	4	5	5	6	7	7	8	9	10	11	11	12	13	14	15	16	17	19
4	5	5	6	6	7	8	8	9	10	10	11	12	13	14	15	16	17	18	19
5	6	6	7	7	8	8	9	10	10	11	12	13	13	14	15	16	17	18	19
6	7	7	8	8	9	9	10	10	11	12	12	13	14	15	15	16	17	18	19
7	7	8	8	9	10	10	11	11	12	12	13	14	14	15	16	17	17	18	19
8	8	9	9	10	10	11	11	12	13	13	14	14	15	16	16	17	18	18	19
9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	17	17	18	19	19
10	10	11	11	12	12	12	13	13	14	14	15	15	16	16	17	18	18	19	19
11	11	12	12	12	13	13	14	14	15	15	15	16	16	17	17	18	18	19	19
12	12	13	13	13	14	14	14	15	15	16	16	16	17	17	18	18	19	19	20
13	13	14	14	14	15	15	15	16	16	16	17	17	17	18	18	18	19	19	20
14	14	15	15	15	15	16	16	16	16	17	17	17	18	18	18	19	19	19	20
15	15	15	16	16	16	16	17	17	17	17	18	18	18	18	19	19	19	19	20
16	16	16	17	17	17	17	17	18	18	18	18	18	19	19	19	19	19	20	20
17	17	17	17	18	18	18	18	18	18	18	19	19	19	19	19	19	20	20	20
18	18	18	18	18	18	19	19	19	19	19	19	19	19	19	19	20	20	20	20
19	19	19	19	19	19	19	19	19	19	19	20	20	20	20	20	20	20	20	20
EUL =	20																		

Table M-41. Adjusted EULs for a 17 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	2	2	3	3	4	5	5	6	7	7	8	9	10	11	12	13	14	15	16
2	3	3	4	4	5	5	6	7	7	8	9	10	10	11	12	13	14	15	16
3	4	4	5	5	6	6	7	7	8	9	9	10	11	12	12	13	14	15	16
4	4	5	5	6	7	7	8	8	9	9	10	11	11	12	13	14	14	15	16
5	5	6	6	7	7	8	8	9	10	10	11	11	12	13	13	14	15	15	16
6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	16	16
7	7	8	8	9	9	10	10	10	11	11	12	12	13	13	14	15	15	16	16
8	8	9	9	10	10	10	11	11	12	12	12	13	13	14	14	15	15	16	16
9	9	10	10	10	11	11	11	12	12	13	13	13	14	14	15	15	16	16	17
10	10	11	11	11	12	12	12	13	13	13	14	14	14	15	15	15	16	16	17
11	11	12	12	12	12	13	13	13	13	14	14	14	15	15	15	16	16	16	17
12	12	12	13	13	13	13	14	14	14	14	15	15	15	15	16	16	16	16	17
13	13	13	14	14	14	14	14	15	15	15	15	15	16	16	16	16	16	17	17
14	14	14	14	15	15	15	15	15	15	15	16	16	16	16	16	16	17	17	17
15	15	15	15	15	15	16	16	16	16	16	16	16	16	16	16	17	17	17	17
16	16	16	16	16	16	16	16	16	16	16	17	17	17	17	17	17	17	17	17
EUL =	17																		

Table M-42. Adjusted EULs for a 15 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	2	2	3	3	4	4	5	5	6	7	7	8	9	10	10	11	12	13	14
2	2	3	3	4	5	5	6	6	7	7	8	9	9	10	11	12	12	13	14
3	3	4	4	5	5	6	6	7	8	8	9	9	10	11	11	12	13	13	14
4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	12	12	13	14	14
5	5	6	6	7	7	8	8	8	9	9	10	10	11	11	12	13	13	14	14
6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	12	13	13	14	14
7	7	8	8	8	9	9	9	10	10	11	11	11	12	12	13	13	14	14	15
8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	13	14	14	15
9	9	10	10	10	10	11	11	11	11	12	12	12	13	13	13	14	14	14	15
10	10	10	11	11	11	11	12	12	12	12	13	13	13	13	14	14	14	14	15
11	11	11	12	12	12	12	12	13	13	13	13	13	14	14	14	14	14	15	15
12	12	12	12	13	13	13	13	13	13	13	14	14	14	14	14	14	15	15	15
13	13	13	13	13	13	14	14	14	14	14	14	14	14	14	14	15	15	15	15
14	14	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	15	15
EUL =	15																		

Table M-43. Adjusted EULs for a 14 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	4	4	5	5	6	6	7	8	8	9	10	11	11	12	13
2	2	3	3	4	4	5	5	6	7	7	8	8	9	10	10	11	12	12	13
3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	11	11	12	13	13
4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	12	12	13	13
5	5	6	6	7	7	7	8	8	9	9	9	10	10	11	11	12	12	13	13
6	6	7	7	7	8	8	8	9	9	10	10	10	11	11	12	12	13	13	14
7	7	8	8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	14
8	8	9	9	9	9	10	10	10	10	11	11	11	12	12	12	13	13	13	14
9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13	13	13	13	14
10	10	10	11	11	11	11	11	12	12	12	12	12	13	13	13	13	13	14	14
11	11	11	11	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14
12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14
13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	14
EUL =	14																		

Table M-44. Adjusted EULs for a 13 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	3	4	4	5	6	6	7	7	8	9	9	10	11	11	12
2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	10	10	11	12	12
3	3	4	4	5	5	6	6	6	7	7	8	8	9	9	10	11	11	12	12
4	4	5	5	6	6	6	7	7	8	8	8	9	9	10	10	11	11	12	12
5	5	6	6	6	7	7	7	8	8	9	9	9	10	10	11	11	12	12	13
6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	11	12	12	13
7	7	8	8	8	8	9	9	9	9	10	10	10	11	11	11	12	12	12	13
8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13
9	9	9	10	10	10	10	10	11	11	11	11	11	12	12	12	12	12	13	13
10	10	10	10	11	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13
11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	13	13	13	13
12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13
EUL =	13																		

Table M-45. Adjusted EULs for a 12 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	9	9	10	11	11
2	2	3	3	4	4	4	5	5	6	6	7	7	8	8	9	10	10	11	11
3	3	4	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	11
4	4	5	5	5	6	6	6	7	7	8	8	8	9	9	10	10	11	11	12
5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	12
6	6	7	7	7	7	8	8	8	8	9	9	9	10	10	10	11	11	11	12
7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12
8	8	8	9	9	9	9	9	10	10	10	10	10	11	11	11	11	11	12	12
9	9	9	9	10	10	10	10	10	10	10	11	11	11	11	11	11	12	12	12
10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	12	12	12	12
11	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12
EUL =	12																		

Table M-46. Adjusted EULs for a 11 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	1	2	2	3	3	3	4	4	5	5	6	6	7	7	8	9	9	10	10
2	2	3	3	3	4	4	5	5	6	6	6	7	7	8	8	9	9	10	10
3	3	4	4	4	5	5	5	6	6	7	7	7	8	8	9	9	10	10	11
4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	11
5	5	6	6	6	6	7	7	7	7	8	8	8	9	9	9	10	10	10	11
6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11
7	7	7	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	11	11
8	8	8	8	9	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11
9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	11	11	11	11
10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11
EUL =	11																		

Table M-47. Adjusted EULs for a 10 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	2	3	3	4	4	5	5	5	6	6	7	7	8	8	9	9
2	2	3	3	3	4	4	4	5	5	6	6	6	7	7	8	8	9	9	10
3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	10
4	4	5	5	5	5	6	6	6	6	7	7	7	8	8	8	9	9	9	10
5	5	5	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10
6	6	6	7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	10	10
7	7	7	7	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10
8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	10	10	10	10
9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10
EUL =	10																		

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
5-11-1	5/6/2011

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APPENDIX N

SPECIAL CIRCUMSTANCE

Introduction

In its October 18, 2010 order[801], the Commission defined early replacement as replacement of equipment prior to the end of its prescribed effective-useful life and directed Staff to develop a dual baseline method for estimating the benefits and costs of early replacement that provides consistency between the treatment of savings and costs. The order also directed Staff to provide simplifying lookup tables for early replacement energy savings consistent with the dual baseline concept. The dual baseline methods and lookup tables have been developed and are provided in Appendix M of the Technical Manual.

The October 18, 2010 Order also introduced the concept of "special circumstance" replacements: the replacement of equipment operated by customers who are influenced by initial costs more than by life cycle economics. These customers include those with insufficient capital, a split incentive (such as a landlord incurring cost to provide a tenant benefit), short time horizons, and/or other factors which tend to prevent long range economic decision-making regarding the installation of high efficiency equipment. The Commission applied the concept of special circumstance replacements only to commercial and industrial machinery and multi-family central systems,[802] and only to equipment well past its prescribed effective useful life. The order specifically excluded lighting equipment from special circumstance replacement.

The Commission established a general outline for determining eligibility for special circumstance replacement treatment including:

Equipment age significantly exceeds its effective useful-life;
Energy consumption significantly exceeds that of current high efficiency models;
There is a history of significant repair or replacement with used equipment;
The prospective next repair or replacement is likely to be much less expensive than replacement with new higher efficiency machinery.

The order directed Staff to develop more detailed criteria and a method for adapting dual baseline screening for early replacement to special circumstance replacements, with consultation with the Evaluation Advisory Group (EAG) that includes the program administrators (PAs). In dual baseline analysis, the savings for the first baseline are calculated against the replaced equipment, while the savings for the second baseline are calculated against the current standards/codes minimums or, in the absence of such, common practice.

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801 Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Consolidation and Revision of Technical Manuals (issued October 18, 2010).

802 What "multi-family central systems" includes is clarified in detail in the Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Modifications to the Technical Manual (issued July 18, 2011), pp 15 - 16.

In the July 18, 2011 order,[803] the Commission approved Staff's proposals regarding detailing the first two criteria for eligibility:[804]

> **Age Rule**: The equipment to be replaced must be aged at least 125% of it is prescribed effective-useful life in cases where the age of the equipment can be determined to this extent.[805] If the equipment is determined to be less than 125% of its EUL, it's not eligible for SC treatment regardless of consumption or any other factor
>
> **Energy Use Rule**: Applies **only** in cases in which the age of the existing equipment cannot be determined relative to 125%; existing equipment of most types must consume at least 20% more energy than the new high efficiency equipment to do the same amount of work, and at least 35% more for chillers.

In the July 18 Order, the Commission also approved Staff's proposal to define the first baseline, the hypothetical period for which the old equipment in place would have continued in use absent the program (the Default Functional Period or DFP) as 25% of the program efficient measure's EUL.[806]

The July 18, 2011 order also directed Staff to post directions and lookup tables for Special Circumstance replacement as a counterpart to those in Appendix M for early replacement. For the interim period, PAs were permitted to use the tables in Appendix M for Special Circumstances for costs.[807] However, Appendix N includes tables for special circumstance replacement that PAs must now use.

For equipment that qualifies as special circumstance, the dual baseline method described in Appendix M will be applied for special circumstance TRC screening. The dual baseline situation that characterizes the special circumstance situation, illustrated in Figure 1, involves a customer who replaces fully functioning equipment aged at least 25% beyond its official EUL. The equipment hypothetically would have continued to function for some period of time, the DFP. However, the customer is induced by the program to replace this existing equipment with more efficient equipment. It is assumed that at the end of the DFP, absent the program, the customer would have installed equipment that would meet the existing efficiency code or appliance standard, or common practice (referred to as the *code/standard equipment*).

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803 Ibid.

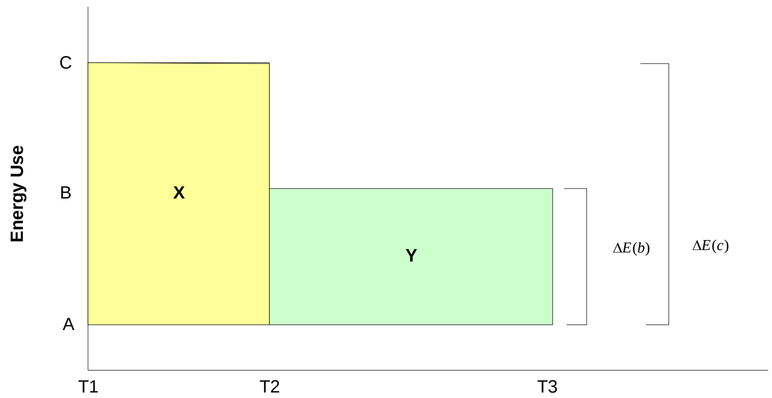
114 While the first two require definition of "significant," the third and fourth do not require or lend themselves to additional detail. The Commission also approved Staff's proposed relationship between the first two, i.e., energy consumption is considered only if age relative to 125% cannot be determined.

805 It is not necessary to determine the exact age of the equipment as long as it can be determined to be at least 125% of the effective-useful life.

806 The Order also included a comprehensive list of measures and associated EULs that should be used in cases where the special circumstance measure matches a measure in the Order. In cases where there is no match, PAs must propose and document the EUL.

807 Program administrators were required to research and calculate their own savings ratios and to use the second set of tables (not the DEER-based tables), as consumption of the old equipment in place may differ between early and special circumstance replacement -- the baseline existing equipment is pre EUL versus 125% past it, potentially with widely varying efficiency. For costs, the comparison is between current high efficiency versus standards/code or common practice in any case.

Figure 2. The Special Circumstance Condition



$\Delta E(c)$ = C - A
$\Delta E(b)$ = B - A
C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3= Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected period of time in which the pre-existing equipment would have continued to function, referred to as the default functional period (DFP)
T3 – T2 = Expected remaining EUL of the new efficient equipment

Energy savings in this example would consist of two portions. The customer would have experienced the ***full*** savings represented by the line segment C-A for the DFP period T2-T1, Area **X**. At the end of the DFP, the savings for the period T3-T2 would be reduced to ***incremental*** savings represented by the line segment B – A, area **Y**. To carry out these calculations, information on the energy use of code/standard equipment is required. Information on energy use of the existing equipment and the high efficiency equipment provided through the program is also required, but much more available and routinely needed.

The costs also have to be calculated in a manner consistent with the special circumstance case. In normal replacement situations, one would use the incremental cost that is defined as the cost of the new efficient equipment minus the cost of the code/standard equipment. In the special circumstance case, the incremental cost is calculated in a slightly different manner, which recognizes, in the absence of the program, the customer would not have purchased any equipment until the future end of the DFP.

Thus, one would first have to determine the full cost of the new efficient equipment at T1 *and* the full cost of the code/standard equipment (both including the installation labor) at T2 (assuming no change in real costs). The incremental costs would then be calculated as the cost of the new efficient equipment installed now (left column in Figure 2) minus the present value (PV) of the cost that is avoided in the future for the code/standard equipment (right column Figure 2). Figure 2 presents a case in which the DFP is 4 years and, absent the program, the code/standard equipment would have been installed in the fifth year. This calculation differs from the normal/end of life replacement incremental cost in adding the time value of money for spending the money earlier.

Figure 3. Incremental Cost Calculation for Special Circumstance Cases with a DFP of Four Years

Year	PV With Program	PV Without Program
1	Full Cost of High Efficient Equipment	0
2	0	0
3	0	0
4	0	0
5	0	Full Cost of Code/Standard Equipment

The Ratio Approach to the Dual Baseline with the Lookup Tables

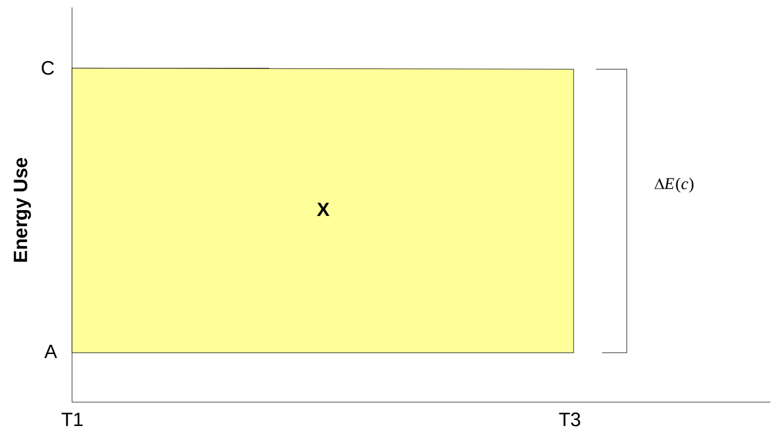
As in Appendix M, this approach focuses on the ratio of incremental energy savings to full energy savings[808] and the ratio of incremental costs to full costs. These ratios, shown at the top of the columns in Tables N-1 through N-2, determine the factors that PAs can use to adjust the savings and cost data. These first two tables require the program administrators to provide their own incremental costs and savings ratios (based on the code/standard equipment). To use these tables, PAs must match the ratios that they have calculated to the nearest corresponding ratios in these tables

To use Table N-1 for benefits, PAs will need to calculate the full annual savings as the annual energy use of the old equipment in place minus the annual energy use of the high efficiency equipment. These full savings are then counted for each year of the EUL as is represented as area *X* in Figure 3. For each year of the EUL (T3 – T1) of the new equipment, the full kWh or therm savings are converted to dollar benefits by multiplying them by the Commission's avoided costs estimates for that year[809].

Figure 5. Inflated Lifecycle Benefits

808 The savings values ratios are not area present values but are rather the line segments in Figure 1 on the vertical axis: (B – A) divided by (C – A).

809 The tables are not territory-specific, but statewide. This is because only the LRAC growth rates matter, not the absolute values, and the growth rates for the various zones are almost identical in the LRACs in use.



$\Delta E(c)$ = C - A
C = Energy use of pre-existing equipment
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T3 = Date on which the new efficient equipment is expected to fail
T3 – T1 = EUL of new efficient equipment

As a preliminary step in using Table N-1, and valid only for that purpose, the PAs will calculate this "inflated lifecycle benefits" for kWh, peak kW, and/or therms as the present value of the stream of full savings benefits for the EUL of the new equipment.[810]

In cases of special circumstance under the ratio approach, it is these inflated lifecycle benefits that must be adjusted using the appropriate *inflated lifecycle benefits adjustment factor*. For a given measure with a given EUL/DFP and ratio of incremental savings to full savings, the inflated lifecycle benefits adjustment factor is the ratio (presented as a percentage) of the present value of the dual baseline lifecycle benefits (X+Y) illustrated in Figure 1 to the present value of the inflated lifecycle benefits illustrated in Figure 3.

Under the Commission requirement of consistent treatment of savings and costs, the full costs[811] must also be adjusted downward. Using research on the costs of standard/code equipment, a PA can calculate the ratios of incremental costs to full costs and obtain the *full cost adjustment factors* from Table N-2. If a PA cannot obtain or chooses not to seek the data necessary to calculate the cost ratios, it can use the ratios and adjustment factors from Tables M-11 through M-19 in Appendix M in cases in which the measures match.

Note that all documentation for PA costs and savings estimates and ratios must be retained for possible Staff or ex post evaluator review.

Look-Up Tables

Tables N-1 and N-2 have been prepared so that PAs can obtain the Inflated Lifecycle Benefit and the Full Cost adjustment factors. For Inflated Lifecycle Benefits Adjustment Factors, PAs must

[810] Usually, the ratio of incremental kWh savings to full kWh saving would be the same as the ratio of incremental peak kW demand reduction to full peak kW demand reduction, which implies using the same ratio and adjustment factor for both. However, with some measure types, such as cooling, PAs may benefit from calculating different ratios of incremental to full for kWh and kW. A PA can choose to use higher 0.05 increment kW ratios if it can calculate and document them with retention.
[811] Full costs include the capital cost of the new efficient equipment plus installation cost.

calculate their own savings ratios. If PAs are able to calculate their own ratios of incremental costs to full costs, they may prefer to use Table N-2. However, as discussed above, in some cases PAs may use the tables in Appendix M to obtain cost ratios and adjustment factors.

For Tables N-1 and N-2, a PA should identify the 0.05 increment ratios that are closest to those it developed. The ratios range from 0.95 to .05 in increments of 0.05, and there are no measure designations.

Note that ratios of 1.0 and 0.0 are not included in the tables. For some measures, the efficiency of the old in place unit is still the common practice or no new standards have been adopted, i.e., the baseline for the full savings and the incremental savings are the same. As a result, the ratio of incremental to full savings is near 1.0, meaning that a PA can claim the full savings for the entire EUL of the new equipment (areas X and Y in Figure 4). Therefore, the lookup tables do not apply. For other measures, the high efficiency equipment subsidized by the program is consistent with current code or standards. For these measures, the incremental savings are zero and thus the ratio of incremental to full savings is 0.0.This means that a PA can claim full savings for only the RUL (area X in Figure 5), after which the high-efficiency replacement would have occurred anyway. Therefore, the lookup tables do not apply.

Figure 4. Efficiency of the Old In Place Unit Is Still the Common Practice Or No New Standards

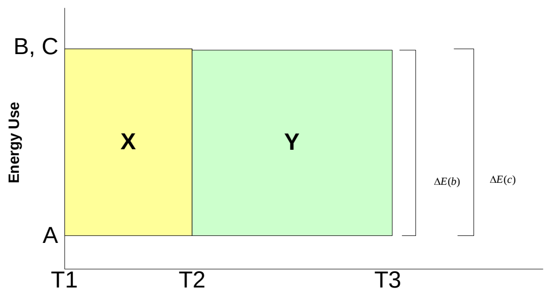
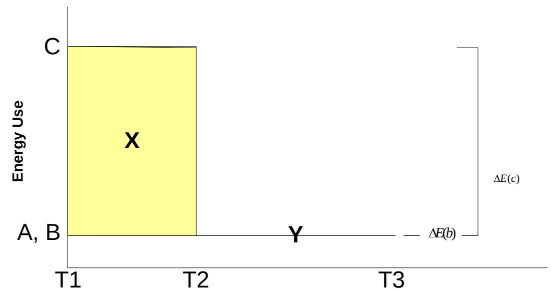


Figure 5. High Efficiency Equipment Subsidized by the Program Is Consistent with Current Code Or Standards



$\Delta E(c)$ = C - A

$\Delta E(b)$ = B - A

C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3= Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected remaining useful life (RUL) of the pre-existing equipment
T3 – T2 = Expected remaining EUL of the new efficient equipment

To use the tables, a PA must gather the following four pieces of information:

- the EUL of the type of equipment,
- the DFP of the old equipment in place (just 25% of the EUL),
- the full savings of the equipment (annual energy use of the old equipment in place minus the annual energy of the high efficiency equipment supported by the program), and
- the full costs (including installation)

Additionally, a PA will need documented estimates, based on equipment minimally compliant with standards/codes or common practice, of incremental savings and costs in order to calculate:

- The ratio of incremental savings to full savings, and
- The ratio of incremental costs to full cost

Again, note that for the costs, PAs can use the Tables in Appendix M where measures match.

Table Organization

Table N-1 contains the Inflated Lifecycle Benefit Adjustment Factors while Table N-2 contains the Full-Cost Adjustment Factors.

In Table N-1, the first row is the ratio of incremental savings to full savings while in Table N-2 the first row is the ratio of incremental to full cost. In both tables, the first two columns identify the EULs and corresponding DFPs:

- 25 Years/6
- 20 Years/5
- 14 to 17 Years/4
- 10 to 13 Years/3

The remaining columns present the respective adjustment factors by ratio of

- Table 1: Incremental savings to full savings
- Table 2: Incremental costs to full costs

Program-Tracking Database Requirements

The program tracking databases contain information for each measure installation which the PAs are required to maintain for the purposes of current reporting and future impact evaluation, the latter requiring many fields not used for current reporting. The following seven additional required variables, as were first required in Appendix M,[812] are being added by Staff through the Evaluation Advisory Group process[813]:

- Type of Installation (TRC Approach)[814] ,
- The Full Savings (kWh or therms),
- If electric, the on-peak demand reductions associated with the Full Savings,
- The *Adjusted Full Cost* (full cost multiplied by the full-cost adjustment factor),
- The Ratio of Incremental Savings to Full Savings,

[812] Note that item #2 above is a correction of item #2 in Section 5 of Appendix M. Furthermore, item #3 is now required in addition to those variables listed in Section 5 of Appendix M. Those using Appendix M should take note of these changes.

[813] Note that for cases of normal replacement and add-on, the variables 2 through 7 should be coded as "n/a" (not applicable).

[814] ER=Early Replacement; NR=Normal Replacement; SC=Special Circumstance; AO=Add On. Add on refers to adding something that replaces nothing. Examples include adding controls to a boiler that had none, or adding insulation where there was none or some. Add-on measures are modeled at full costs and full savings for the length of their EULs. The full savings are reported toward first-year goals.

- The Ratio of Incremental Costs to Full Costs, and
- The *Adjusted EUL* (discussed below).

The Adjusted EUL is defined as that period of years over which the present value benefits of the full savings would approximate the present value dollar benefits of the underlying dual baseline. Figure 6 shows the Adjusted EUL Tx, reduced from the actual EUL T3 such that the lifecycle savings over the period Tx – T1 approximates the lifecycle savings over the period T3 – T1 in Figure 1 (repeated from above). The longer the DFP is, the longer the adjusted EUL, owing to more years at full savings.

Figure 1. Lifecycle Savings: Dual Baseline

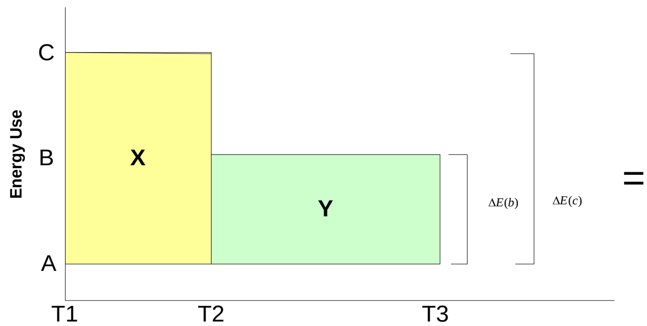


Figure 6: Lifecycle Savings: Approximation to Dual Baseline

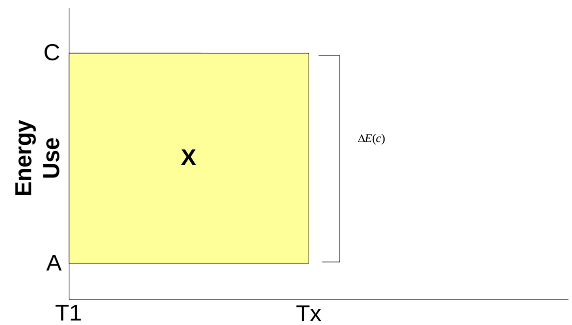


Table N-3 presents the adjusted EULs in years for each possible ratio (in 0.05 increments). In Table N-3, the first row is the incremental to full savings ratio and the first two columns identify the EULs and corresponding DFPs. The adjusted EUL is not used for TRC screening, but only for the program's tracking database. Table N-3 is organized in the same way as the Table N-1. Note that Tables N-1 through N-3 are also available in Excel.

Example

Consider the following example. Suppose a PA finds in place equipment with an EUL of 17 years whose age is determined to be 22 years. The five years over the EUL is greater than 25% of the EUL (17/4 = 4.25 which rounds to 4, which is also the DFP). The equipment is eligible for special circumstance treatment if it also meets criteria #3 and #4. The PA has determined that the ratio of incremental savings to full savings is 0.65 and the ratio of incremental costs to full costs is 0.40. To find the Inflated Lifecycle Benefits Adjustment Factors, the Full Cost Adjustment Factors, and the Adjusted EUL for this measure, the PA must go to Table N-1 and identify the row for measures with an EUL of 17 years and a DFP of 4 years. Next, they must identify the column with an incremental savings to full savings ratio of 0.65. The value in the intersection of this row and this column is 0.75, which is the Inflated Lifecycle Benefits Adjustment Factor. Using Table N-3, the same procedure would be followed to obtain the Adjusted EUL of 10 years.

To find the Full Cost Adjustment Factor, the PA would go to Table N-2, find the row with a 4-year DFP and the column with a ratio of 0.40. The value in the cell is 0.52, which is the Full Cost Adjustment Factor. As discussed above, in some cases PAs may use the tables in Appendix M to obtain cost ratios and adjustment factors.

The next step is to multiply the inflated benefits by the benefits factor and the full costs by the costs factor. For Total Resources Cost (TRC) analysis, ratio the two products, benefits/costs. For first year savings to report against approved program goals, for special circumstances replacements PAs would use the full savings, the first baseline of the existing equipment versus the high efficiency program measure.

Table N-1. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings, by DFP, for kWh, kW, and Therm Savings

	DFP	Median Ratio of Incremental Savings to Full Savings																		
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
		Inflated Lifecycle Benefit Adjustment Factors																		
25 Year EUL	6	42%	42%	47%	52%	52%	56%	60%	64%	64%	68%	71%	75%	78%	81%	84%	86%	91%	94%	96%
20 Year EUL	5	42%	42%	47%	47%	53%	53%	58%	63%	63%	67%	72%	76%	76%	80%	84%	87%	91%	94%	97%
17 to 14 Year EUL	4	35%	43%	43%	50%	50%	56%	56%	63%	63%	69%	69%	75%	75%	80%	86%	86%	91%	95%	95%
13 to 10 EUL	3	32%	41%	41%	41%	50%	50%	58%	58%	66%	66%	66%	73%	73%	81%	81%	87%	87%	94%	94%

Table N-2. Full Cost Adjustment Factors for PA-Supplied Ratios of Incremental Cost to Full Cost, by DFP

	DFP	Median Ratio of Incremental Cost to Full Cost																		
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
		Full Cost Adjustment Factors																		
25 Year EUL	6	31%	35%	38%	42%	46%	49%	53%	56%	60%	64%	67%	71%	75%	78%	82%	85%	89%	93%	96%
20 Year EUL	5	27%	31%	35%	39%	43%	46%	50%	54%	58%	62%	66%	69%	73%	77%	81%	85%	89%	92%	96%
17 to 14 Year EUL	4	23%	27%	31%	35%	39%	43%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%
13 to 10 EUL	3	19%	23%	28%	32%	36%	40%	45%	49%	53%	57%	62%	66%	70%	74%	79%	83%	87%	91%	96%

Table N-3. Adjusted EULs, by DFP

	DFP	Median Ratio of Incremental Savings to Full Savings																		
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
		Adjusted EULs in Years																		
25 Year EUL	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	16	16
20 Year EUL	5	6	6	7	7	8	8	9	10	10	11	12	13	13	14	15	16	17	18	19
17 to 14 Year EUL	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	12	12	13	14	14
13 to 10 EUL	3	3	4	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	11

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010

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APPENDIX O

COMMERCIAL AND INDUSTRIAL LIGHTING POLICY

INTRODUCTION

On January 12, 2011 Staff issued a SAPA Notice, in part on proposals to implement directives in the Commission's October 18, 2010 order in Case 07-M-0548 regarding benefit/cost analysis for Special Circumstance customers in Energy Efficiency Portfolio Standard (EEPS) programs.[815] In its 2/28/11 comments, National Grid sought clarification regarding: whether field staff must determine the age of lighting fixtures in place and how to treat lighting replacement where the age of the fixture in place is past its prescribed effective useful life (EUL). With regard to these lighting issues, the Commission in its July 18, 2011 order in the EEPS proceeding directed[816] "the Implementation Advisory Group to attempt to resolve the issues of determining the age of lighting equipment and the correct approach for valuing savings from lighting replacements[817] under the mechanism we provided for modifying the Consolidated Technical Manual [CTM] in our June 20, 2011 Order in this proceeding."[818]

Regarding commercial and industrial lighting issues,[819] the technical manual, effective 1/1/11 [*as modified September 2012]*, states: "The baseline condition is assumed to be the existing *[and operational]* lighting fixture in *[all applications other than new construction or extensive renovations which trigger the building code*]." This makes the savings baseline and costs for TRC analysis independent of the age of the operational fixture. This approach reflects the frequent impracticality of determining the age of lighting fixtures

Absent this provision, replacement of fixtures in place which are either (1) irreparable (unusable and not economic to repair) or, (2) operating and not demonstrably younger than their EUL (in short, broken or past EUL) would be treated as normal/end of life replacement: modeled with incremental costs and with incremental savings for the full EUL of the new measure, including for first year scorecard reporting.[820] Fixtures in place in working order and demonstrably aged below their EUL would get early replacement treatment which, for most non-lighting measures, would mean dual baseline treatment per Appendix M. Appendix M, however, excludes lighting from such treatment.[821] Therefore, the conventional early replacement modeling of full costs and full savings would still apply, with the full savings against the old fixture in place modeled for the full EUL of the new equipment and reported as first year scorecard savings.

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815 SAPA 07-M-0548SP30 - Proceeding on Motion of the Commission Regarding an Energy Efficiency Portfolio Standard.

816 Case 07-M-0548, Order Approving Modifications to the Technical Manual, pp. 16-17.

817 Savings are related to the type of lamp used in the fixture.

818 New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, October 15, 2010, p. 109, www.dps.ny.gov/Tech ManualNYRevised10-15-10.pdf

819 C&I lighting includes multi-family building common areas for the purposes of this paper.

820 Incremental means the costs and consumption of the high efficiency model promoted by the program minus the costs and consumption of the standard efficiency level alternative – Federal minimum appliance standards, State building codes or, in the absence of codes and standards, the common practice.

821 Appendix M, posted with Technical Manual, see footnote #5, p. 10.

In compliance with instructions stated in the July 18, 2011 Order, this appendix prescribes principles for C&I lighting replacements, both replacements of operational fixtures and irreparable fixtures, addressing:

- Replacements for which incentive funding is precluded, as a practical matter of presumptive TRC failure by definition,
- Inputs for TRC ratio calculations,
- Age determination requirements (none), and
- Values for reporting as first year annualized savings against targets approved in orders (the same as the first year savings modeled in the TRC analysis).

THE OVERALL PRINCIPLES

If a lighting fixture of any age is operational, replacement is early replacement. The full savings against the fixture in place[822], will be reported as first year savings and modeled for the full EUL of the replacement measure in TRC screening. Costs will be full costs, the total costs of the replacement, as is usual for early replacement analysis outside Appendix M.[823]

For irreparable lighting fixtures, normal/end of life rules apply: incremental savings and costs between the common practice and the high efficiency measures promoted by EEPS are used for TRC analysis; incremental savings are used for first year scorecard savings; and no age determination is required.

DISCUSSION BY TYPE OF EQUIPMENT REPLACED

The lighting upgrades considered here are; screw-in incandescent fixtures (which will evolve toward use of halogen lamps)[824] replaced with CFL or LED fixtures. Linear fluorescent T12 or standard T8 replaced with Super T8s, T5s or LEDs.[825] The fixtures in place may be either in good working order (early replacement) or irreparable (normal replacement).

Baselines: Screw-In Fixtures

Screw-in fixtures are expected to continue to accommodate the least efficient lamp types which still meet the national lighting standards established under the Energy Independence and Security Act of 2007 (EISA).Therefore, the baseline choice for early or normal replacement with any pin-based fixtures remains screw-in fixtures: either to keep a working fixture in place or to replace an irreparable one with a new screw-in fixture. Once the EISA standard is phased-in for a particular lamp size the least efficient lamp technology meeting the standard would normally be considered the baseline. Incandescent lamps, however, are expected to remain in inventories for sale and are reportedly being stockpiled. A screw-in fixture can house, for baseline consumption relative to

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822 The full savings differs from incremental savings in subtracting the consumption of the fixture supported by the program from the consumption of the fixture in place, not from the consumption of the current common alternative.

823 If passing the TRC, however, is a concern, PAs may choose to document an age past the EUL to be able to model the incremental costs used re: normal replacement as opposed to the full costs usual for early replacement.

824 Halogen lamps consume approximately 72% as much as incandescent lamps. Whereas the TRM reports a delta of watts consumption of 2.53 between CFLs and incandescent lamps, the delta would be approximately 1.55 for CFLs against halogen lamps. This means that 1.55 times the CFL wattage is the savings delta against a halogen lamp.

825 Speaking only of the types whose replacement are usual subjects of EEPS programs, thus not including high intensity discharge (HID) fixtures, metal halide, high pressure sodium, mercury vapor, *or CFLs or LEDs yet*. Perhaps at some point it will be cost effective to replace CFLs with LED lamps.

CFLs, either incandescent or halogen lamps. Therefore, baselines will be based upon deemed years, for each wattage range, in which installation of the new common practice technology, halogen lamps, is more likely than installation of stockpiled incandescent lamps.[826] Until reconsideration (based on studies in progress and program experience) in March 2015, incandescent lamps will remain the baseline.

For fixtures compatible with incandescent and halogen lamps, TRC analysis of a measure or project may be occurring before the deemed switch year or after it. Analysis done before the estimated switch year will entail two baselines of consumption during the EUL of the screw-in alternative to CFL.[827] The first baseline will be incandescent lamp consumption until the beginning of the deemed switch year,[828] the second baseline being halogen lamp consumption. In future TRC analysis after the deemed switch dates, the baseline for incremental savings will be halogen lamps against CFLs throughout.

Baselines: Linear Fluorescent Fixtures

For early replacement of an operational T12 fixture, the baseline relative to super T8s is simply the consumption of the T12 lamp. For normal replacement of an irreparable T12 fixture, the baseline, until reconsideration (based on studies in progress and program experience) in March 2015, is the consumption of a T12. At some point, customers will no longer be installing relatively inefficient T12 fixtures in significant numbers as lamp availability decreases[829] and therefore standard T8s will be the common practice and thus the suitable linear fluorescent baseline for consideration of appropriate super T8s and T5s.

<u>ELIGIBILITY FOR REBATES</u>

The next issue is potential cost-effectiveness and thus measures' eligibility for rebates. Incentives for CFL (and potentially for LED lamp) pin fixtures, as needed and if cost- effective, may continue to be appropriate for some years to come.[830] Incandescent/halogen fixtures may remain in use indefinitely, with halogens being less expensive upfront as well as more familiar looking than CFLs or LED lamps. Replacement of screw-in fixtures with new screw-in fixtures may continue, and thus incentives for replacement with higher efficiency technologies make sense.

Turning to rebate-eligibility of linear fluorescent fixtures, since installation of T12 fixtures will be unlikely at some point and replacement of a standard T8 fixture with a standard T8 fixture would yield no savings. At that point, savings will exist and cost-effective incentives will be payable only for installation of super T8s (or T5s) in watts-saving configurations. Super T8s produce more lumens per watt and have improved color rendering and a longer rated life, but since ratepayers should not pay for extra lumens, incentives should be paid only for projects which reduce the overall wattage of fixtures relative to standard T8s.

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[826] While in reality the technology mixes will shift gradually, the baselines as executed here will require selection of the year in which the probable majority choice will switch.

[827] Screw-in LEDs are unlikely in the C&I context in which quality concerns require LED fixtures.

[828] While incandescent lamps installed before the switch year may remain in use during it, this would probably be for a short time given the usual heavy C&I usage. Additionally, fractional year modeling is not practical.

[829] This will not happen often enough to justify ratepayer subsidy of all replacements to avoid the occasional instance. Retrogression from T8 to T12 is particularly unlikely.

[830] This is also applicable for screw-in CFLs for incandescent/halogen fixtures.

COSTS TO BE MODELED

The last issue is costs to be modeled in TRC screening. For early replacement of operational, screw-in incandescent/halogen fixtures, the TRC screening would as usual include the full *costs* of the replacement, additionally owing to the indefinite remaining life of the fixture in place, and to the continued availability of inexpensive screw-in fixtures usable for halogen. Since most equipment replaced will be in working order, the full-costs case will be the most common, but with incremental costs for normal replacement of irreparable fixtures.

Turning to costs to be modeled for linear fluorescent fixtures, operational standard T8s can remain in place for some years, and therefore full costs for early replacement are fully appropriate. If age past the EUL is documented, however, PAs may model incremental costs for normal replacement. Also as a case of normal replacement, since irreparable standard T8 fixtures can be replaced with like, the modeling of incremental costs for super T8 fixtures is justified.

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
3-3-1	3/14/2013

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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	Clothes Washer	Residential	11	DEER 2014 EUL ID: Appl-EffCW
	Clothes Dryer	Residential	14	ENERGY STAR® M&I Scoping Report[831]
	Dehumidifier	Residential	12	ENERGY STAR® Calc[832]
	Air Purifier (Cleaner)	Residential	9	ENERGY STAR® Calc[833]
	Dishwasher	Residential	11	DEER 2014 EUL ID: Appl-EffDW
	Refrigerator and Freezer Replacement	Residential	14	DEER 2014 EUL ID: Appl-ESRefg
	Soundbar	Residential	7	RPP Product Analysis[834]
Appliance Control	Advanced Power Strips	Residential	8	DEER 2014 EUL ID: Plug-OccSens
Appliance Recycling	Air Conditioner - Room (RAC) Recycling	Residential	3	DEER 2014 EUL ID: HV-RAC-RUL
	Refrigerator Recycling	Residential	5	DEER 2014 EUL ID: Appl-RecRef
	Freezer Recycling	Residential	4	DEER 2014 EUL ID: Appl-RecFrzr
Building Shell	Air Leakage Sealing	Residential	15	GDS[835]
	Hot Water and Steam Pipe Insulation	Residential	15	GDS[836]

[831] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[832] ENERGY STAR® Dehumidifier Calculator https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[833] 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
[834] Retail Products Platform Product Analysis, Last Updated May 25, 2016. Available from: https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view
[835] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[836] Ibid.

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Building Shell	Opaque Shell Insulation	Residential	20	DEER 2014 EUL ID: BS-WallIns, BS-CeilIns
	Window & Through-the-Wall Air Conditioner Cover and Gap Sealer	Residential	5	See note below[837]
	Window Replacement	Residential	20	DEER 2014 EUL ID: BS-Win
Domestic Hot Water	Heat Pump Water Heater (HPWH) – Air Source [838]	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[839]
	Storage Water Heater - Electric	Residential	13	DEER 2014 EUL ID: WtrHt-Res-Elec
	Instantaneous Water Heater	Residential	20	DEER 2014 EUL ID: WtrHt-Instant-Res
Domestic Hot Water - Control	Faucet – Low-Flow Aerator	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Thermostatic Shower Restriction Valve	Residential	10	UPC[840]
	Shower Head – Low Flow	Residential	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Drain Water Heat Recovery	Residential	30	2019 Title 24[841]
Heating, Ventilation and Air Conditioning (HVAC)	Refrigerant Charge Correction & Tune-Up – Air Conditioner and Heat Pump	Residential	10	DEER 2014 EUL ID: HV-RefChrg
	Air Conditioner – Central (CAC)	Residential	15	DEER 2014 EUL ID: HV-ResAC
	Air Conditioner – Room (RAC)	Residential	12	GDS[842]

837 At least one manufacturer's warranty period. www.gss-ee.com/products.html

838 Electric heat pump used for service hot water heating

839 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

840 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.

841 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

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	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 Tune-Up	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Circulator Pump – with Electronically Commutated (EC) Motor for Hydronic Distribution	Residential	15	DEER 2014 EUL ID: Motors-pump
	Combination ("Combi") Boiler and Furnace	Residential	20	DEER[843]
	Duct Sealing and Insulation	Residential	18	DEER 2014 EUL ID: HV-DuctSeal
	Blower Fan - with Electronically Commutated (EC) Motor for HVAC Distribution	Residential	15	DEER 2014 EUL ID: Motors-fan
	Furnace, Gas Fired	Residential	22	DOE[844,845]
	Furnace Tune-Up	Residential	5	DEER 2014 EUL ID: BlrTuneup
	Heat Pump - Air Source (ASHP)	Residential	15	DEER 2014 EUL ID: HV-Res HP
	Heat Pump – Ground Source (GSHP)	Residential	25	ASHRAE[846]
	Heat Pump – PTHP	Residential	15	DEER 2014 EUL ID: HVAC-PTHP
	Unit Heater, Gas Fired	Residential	13	ASHRAE Handbook, 2015

843 Based on DEER value for high efficiency boiler and instantaneous water heater

844 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

845 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

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

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
HVAC - Control	Outdoor Temperature Setback Control for Hydronic Boiler	Residential	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.)	N/A
	Steam Traps Repair or Replace	Residential	6	DEER 2014 EUL ID: HVAC-StmTrp
	Submetering	Multifamily	10	NYSERDA[847]
	Thermostat – Programmable Setback Thermostat – Wi-Fi (Communicating) Thermostat – Learning	Residential	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve – One Pipe Steam Radiator	Multifamily	15	DOE[848]
Lighting	Compact Fluorescent Lamp (CFL)	Residential	Coupon – 5	GDS
			Direct Inst. – 7	GDS
			Markdown - 7	GDS
		Multifamily Common Area	9,000 hrs/ annual lighting operating hrs	See note below[849]
	LED Lamps (Directional)	Residential/ Multifamily Common Area	25,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR® Lamps[850]
			35,000 or 50,000 hours	DLC[851]
	LED Lamps (Decorative & Omnidirectional)	Residential/ Multifamily Common Area	15,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR® Lamps

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[847] NYSERDA Residential Electric Submetering Manual

[848] U.S. DOE, "Thermostatic Radiator Valve Evaluation", January 2015, Table 4. Cost-Benefit Financial Assumptions, pg. 16

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

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

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

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting	Light Fixture	LED (Interior)	Residential/ Multifamily	25,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR® Fixtures[852]
		LED (Exterior)	Residential/ Multifamily Common Area	35,000 hrs/ annual lighting operating hrs or 20 yrs (whichever is less)	ENERGY STAR® Fixtures
		Linear Fluorescent	Residential / Multifamily Common Area	70,000 hrs / annual lighting operating hrs, or 15 yrs (whichever is less)	DEER 2014[853] EUL ID: ILtg-Lfluor-CommArea
		CFL	Residential / Multifamily Common Area	22,000 hrs / annual lighting operating hrs, or 20 yrs (whichever is less)	See note below[854]
Lighting Control	Bi-Level Lighting		Multifamily Common Area	15	ComEd[855]
Motors and Drives	Pool Pumps		Residential	10	DEER 2014 EUL ID: OutD-PoolPump
Other	Gas Pool Heater		Residential	8	DOE[856]

[852] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.0, May 2015, p. 17 (Capped at 20 years).
https://www.energystar.gov/sites/default/files/Luminaires%20V2%200%20Final.pdf
[853] Basis value 70,000 hours, capped at 20 years, is common given redecoration patterns
[854] Basis value 22,000 hour ballast life per US EPA. Capped at 20 years as above (2.5 hours per day average lamp operation)
[855] 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
[856] DOE, Chapter 8, Life-Cycle Cost and Payback Period Analyses, Table 8.75 Available from:
https://www.regulations.gov/document?D=EERE-2006-STD-0129-0170

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural Equipment - Control	Engine Block Heater Timer	C&I	8	See note below[857]
Appliance	Clothes Dryer	C&I	14	ENERGY STAR®M&I Report[858]
	Electric & Gas Cooking Equipment	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[859]
	Refrigerators & Freezers	C&I	12	DEER 2014 EUL ID: Cook-SDRef
	Ice Maker	C&I	10	DEER 2014 EUL ID: Cook-IceMach
Appliance - Control	Tier 1 Advanced Power Strips	C&I	8	DEER 2014 EUL ID: Plug-OccSens
	Vending Machine and Novelty Cooler Control	C&I	5	DEER 2014 EUL ID: Plug-VendCtrler
Appliance Recycling	Air Conditioner – Room (Window)	C&I	9	DEER 2014 EUL ID: HV-RAC-ES
Building Shell	Cool Roof	C&I	15	DEER 2014 EUL ID: BldgEnv-CoolRoof
	Hot Water and Steam Pipe Insulation	C&I	15	GDS[860]
	Window - Film	C&I	10	DEER 2014 EUL ID: GlazDaylt-WinFilm
	Window - Glazing	C&I	20	DEER 2014 EUL ID: BS-Win
	Opaque Shell Insulation	C&I	30	ET & CEC[861]
Compressed Air	Air Compressor	C&I	13	Other State TRMs[862]
	Air Dryer - Refrigerated	C&I	15	UI and CL&P[863]
	Engineered Air Nozzle	C&I	15	Wisconsin PSC[864]

[857] Based on EUL's for similar control technology
[858] ENERGY STAR® Market & Industry Scoping Report: Residential Clothes Dryer, November 2011.
[859] 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
[860] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures
[861] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.
[862] Based on a review of TRM assumptions from Ohio (August 2010), Massachusetts (October 2015), Illinois (February 2017) and Vermont (March 2015). Estimates range from 10 to 15 years.
[863] UI and CL&P, Program Savings Documentation for 2007 Program Year, September 2006, pg. 224
[864] PA Consulting Group (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Compressed Air	No Air Loss Water Drain	C&I	13	MA Measure Life Study C&I Retrofit EUL[865]
Domestic Hot Water (DHW)	Domestic Hot Water Tank Blanket	C&I	7	DEER
	Indirect Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Storage Tank Water Heater	C&I	15	DEER 2014 EUL ID: WtrHt-Com
	Instantaneous Water Heater	C&I	20	DEER 2014 EUL ID: WtrHt-Instant-Com
	Heat Pump Water Heater - Air Source (HPWH)	C&I	10	DEER
DHW - Control	Faucet – Low-Flow Aerator	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Aertr
	Low-Flow Salon Valves	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Showerhead – Low-Flow	C&I	10	DEER 2014 EUL ID: WtrHt-WH-Shrhd
	Low-Flow Pre-Rinse Spray Valve	C&I	5	GDS
Heating, Ventilation and Air Conditioning (HVAC)	Refrigerant Charge Correction & Tune Up – CAC and ASHP	C&I	10	DEER 2014 EUL ID: HVAC-RefChg
	Air Conditioner – Unitary	C&I	15	DEER 2014 EUL ID: HVAC-airAC
	Air Conditioner – PTAC	C&I	15	DEER 2014 EUL ID: HVAC-PTAC
	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
	Chiller System Tune-Up	C&I	5	WI EUL DB[866]
	Combination (“Combi”) Boilers and Furnaces	C&I	20	DEER[867]
	Condensing Unit Heater	C&I	18	Ecotope[868]
	Duct Sealing and Insulation	C&I	18	DEER 2014 EUL ID: HVAC-DuctSeal
	Blower Fan – with Electronically Commutated (EC) Motor for HVAC Distribution	C&I	15	DEER 2014 EUL ID: Motors-Fan
	Economizer – Air Side, with Dual Enthalpy Control	C&I	10	DEER 2014 EUL ID: HVAC-addEcono

[865] 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
[866] Wisconsin Public Service Commission: Equipment Useful Life Database, 2013
Excerpt available from: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
[867] Based on DEER value for high efficiency boiler and instantaneous water heater
[868] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)	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
	Boiler Tune-Up	C&I	5	DEER 2014 EUL ID: BlrTuneup
	Furnace, Gas Fired	C&I	23	DOE[869],[870]
	Unit Heater, Gas Fired	C&I	13	ASHRAE Handbook, 2015
	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
	Water Source Heat Pumps	C&I	25	ASHRAE[871]
	Variable Refrigerant Flow	C&I	15	DEER 2014 EUL ID: HVAC-VSD-pump
	Infrared Heater	C&I	17	GDS[872]
HVAC - Control	Thermostat – Programmable Thermostat – Wi-Fi (Communicating)	C&I	11	DEER 2014 EUL ID: HVAC-ProgTStats
	Thermostatic Radiator Valve	C&I	15	DOE[873]
	Outdoor Temperature Setback Control for Hydronic Boilers	C&I	EUL = RUL of Existing Boiler = Boiler EUL – (Current Year – Year of Mfr.)	N/A
	Demand Controlled Ventilation (DCV)	C&I	15	DEER 2014 EUL ID: HVAC-VSD-DCV
	Energy Management System	C&I	15	DEER 2014 EUL ID: HVAC-EMS

[869] 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

[870] 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

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

[872] 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

[873] 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
HVAC – Control	Guest Room Energy Management System	C&I	15	DEER 2014 EUL ID: HVAC-EMS
	Steam Traps Repair/Replace	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
Lighting	CFL Lamp	C&I	9,000 hours /annual lighting operating hours	See note below[874]
	CFL Light Fixture	C&I	12	DEER 2014 EUL ID: ILtg-CFLfix-Com
	HID	C&I	70,000 hours /annual lighting operating hours or 15 years (whichever is less)	DEER 2014 EUL ID: ILtg-HPS
	Linear Fluorescent	C&I	70,000 hours /annual lighting operating hours or 15 years, (whichever is less)	DEER 2014[875] EUL ID: ILtg-Lfluor-Elec
	LED Fixtures (other than refrigerated case)	C&I	50,000 hours /annual lighting operating hours or 20 years (whichever is less)	DLC[876]
			35,000 hours /annual lighting operating hours or 20 years (whichever is less)	ENERGY STAR®[877]
			25,000 hours /annual lighting operating hours or 20 years (whichever is less)	Uncertified
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED

[874] Based on reported annual lighting operating hours; default value by space type in the technical manual (pp. 109-110)
[875] Basis Value 70,000 hours, capped at 15 years to reflect C&I redecoration and business type change patterns
[876] 50,000 hours per L_{70} requirements prescribed by the DLC's Product Qualification Criteria, Technical Requirement Table version 4.2
[877] Placed on the Qualified Fixture List by ENERGY STAR®, according to the appropriate luminaire classification as specified in the ENERGY STAR® Program requirements for Luminaires, version 2.0. Divided by estimated annual use, but capped at 20 years regardless (consistent with C&I redecoration and business type change patterns

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	LED Screw-In Lamps	C&I	15,000 hours (decorative) or 25,000 hours (all other)/ annual lighting operating hours or 20 years (whichever is less)	ENERGY STAR®
Lighting - Control	Interior Lighting Control	C&I	8	DEER 2014 EUL IDs: GlazDaylT-Dayltg, ILtg-OccSens
	Bi-Level Lighting	C&I	15	ComEd[878]
	Plug-Load Occupancy Sensor	C&I	8	DEER[879]
Motors and Drives	Motor Replacement	C&I	15	DEER 2014 EUL ID: Motors-HiEff
	Variable Frequency Drive – Fan and Pump	C&I	15	DEER 2014 EUL ID: HVAC-VSDSupFan
Process Equipment	Steam Trap Repair or Replace – Other Applications	C&I	6	DEER 2014 EUL ID: HVAC-StmTrp
Refrigeration	Air-Cooled Refrigeration Condenser	C&I	15	DEER 2014 EUL ID: GrocSys-Cndsr
	Equipment (Condensers, Compressors, and Sub-cooling)	C&I	15	DEER
	Evaporator Fan Motor – with Electronically Commutated (EC) Motor for Refrigerated Case and Walk-In Cooler	C&I	15	DEER 2014 EUL ID: GrocDisp-FEvapFanMtr
	Refrigerated Case Night Cover	C&I	5	DEER 2014 EUL ID: GrocDisp-DispCvrs
	Auto/Fast Close Door Walk-In Coolers/Freezers	C&I	8	DEER
	Freezer and Cooler Door Gaskets	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
	Freezer and Cooler Door Strip	C&I	4	DEER 2014 EUL ID: GrocWlkIn-StripCrtn, GrocWlkIn-WDrGask
Refrigeration - Control	Anti-Condensation Heater Control	C&I	12	DEER 2014 EUL ID: GrocDisp-ASH
	Evaporator Fan Control	C&I	16	DEER 2014 EUL ID: Groc-WlkIn-WEvapFMtrCtrl
	Condenser Pressure and Temperature Controls	C&I	15	DEER

[878] 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
[879] DEER value for lighting occupancy sensors

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

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FORMS

TYPICAL MEASURE HEADINGS

Measure Name ____

Measure Description ____

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (savings\ equation)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times (savings\ equation) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times (savings\ equation)$$

WHERE:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes

Coincidence Factor (CF)

The prescribed value for the coincidence factor is ________

Baseline Efficiencies from which Savings are Calculated

____

Compliance Efficiency from which Incentives are Calculated

____

Operating Hours

____

Effective Useful Life (EUL)

Years: ___________________
Source: ____

Ancillary Fossil Fuel Savings Impacts

____

Ancillary Electric Savings Impacts

____

References

1. ____

Record of Revision (example)

Record of Revision Number	Issue Date
(example) 8-26-2014	(example) 8/29/2014

Record of Revision

Record of Revision Number	Issue Date
0	12/10/2014

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GLOSSARY

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

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

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

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

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

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

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

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

Record of Revision

Record of Revision Number	Issue Date
0	12/10/2014
6-15-4	6/1/2014
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3-18-22	3/29/2018

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