New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM)

RECORD OF REVISION					
Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
6-14-1	6/19/14	6/20/14-9/19/14	Window/Through the Wall AC Cover/Gap Sealer	Window/Through the Wall AC Cover/Gap Sealer: Adds this new measure to the Multi-family Section	N/A – New Measure
6-14-2	6/19/14	6/20/14-9/19/14	Thermostatic Shower Restriction Valve	Thermostatic Shower Restriction Valve: Adds this new measure to the Single and Multifamily Sections.	N/A – New Measure

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Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
3-14-1	3/17/14	3/18/14-6/17/14	Appendix A	**Prototypical Building Descriptions** Adds an additional multi-family building identified as “Pre-war uninsulated brick”. Affects both low-rise and high-rise multi-family buildings.	Pgs. 212 - 217
3-14-2	3/17/14	3/18/14-6/17/14	Appendix G	**Heating and Cooling Equivalent Full-Load Hours (EFLH)** Adds the corresponding EFLH values for heating and cooling to the respective multi-family building tables. Completes the previously incomplete tables for multi-family high rise heating and cooling.	Pgs. 430 - 435
3-14-3	3/17/14	3/18/14-6/17/14	Appendices A & G	Changes previous building vintage names to better reflect time period in which vintage was constructed. See table 3-14-3 (A) below.	Pgs. 212 – 217 & 430 - 435

<u>Table 3-14-3 (A)</u>

Previous name/vintage	**Revised name/vintage**
N/A	Pre-war uninsulated brick
Older, poorly insulated	Prior to 1979
Existing, average insulation	From 1979 through 2006
New construction	From 2007 through the present

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11-13-1	11/26/13	12/1/13-2/31/14	Dehumidifiers	**Energy Star Dehumidifier** Revises savings estimates based on latest Energy Star® criteria.	Pg. 105
11-13-2	11/26/13	12/1/13-2/28/14	Water Heaters	**Water Heater, Indirect Water Heater, Heat Pump Water Heater** Adjusts conversion factor of Btu/gallon-^{0}F and aligns compliance efficiencies for gas and electric water heaters with NYS Energy Conservation Construction Code	Pgs. 79, 81, 82, 84, 87, 89, 91
11-13-3	11/26/13	12/1/13-2/28/14	Effective Full Load Hours (EFLH) for Heating and Cooling	**Heating and Cooling Equivalent Full-Load Hours (Appendix G)** Corrects labeling of "Office Building" category in EFLH cooling table to "Large Office Building" category; adds the category "Dormitory" to the EFLH heating table; consolidates the previously separated EFLH cooling values into one table.	Pgs. 430-435

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Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
9-13-1	9/27/13	10/1/13-12/31/13	Primary Refrigerators	**Refrigerator Rebates**	N/A – New Section
9-13-2	9/27/13	10/1/13-12/31/13	Refrigerators and Freezers	**Refrigerator and Freezer Recycling**	Pgs. 22-23
9-13-3	9/27/13	10/1/13-12/31/13	Weighting Factors for Commercial Building Calculations (Appendix B)	**Weighting Factors for Commercial Building Calculations (Appendix B)**	Pg. 253
8-13-1	8/31/13	9/1/13 – 11/30/13	Furnaces and Steam Boilers	**Furnace and Boilers (Commercial):** Corrects Record of Revision number 7-13-11 in two ways. 1) Minimum efficiency for gas furnaces less than 225 kBtu/hr is 78% AFUE **or** 80% thermal efficiency(E_t). 2) Minimum efficiency for steam boilers with greater than 2,500 kBtu/hr capacity is 80% combustion efficiency(E_c).	Pg. 137
8-13-2	8/31/13	9/1/13 – 11/30/13	Boilers (Residential) and Furnaces and Boilers (Commercial)	**Boilers (Residential): Compliance Efficiency from which Incentives are Calculated** Clarifies that the table containing the baseline efficiencies from which incentives are calculated is a recommendation by DPS and not policy. **Furnaces and Boilers (Commercial): Compliance Efficiency from which Incentives are Calculated** Clarifies that the table containing the baseline efficiencies from which incentives are calculated is a recommendation by DPS and not policy.	Pgs. 49 & 137

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RECORD OF REVISION					
Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
7-13-1	7/31/13	8/1/13-10/31/13	Building Type Descriptions	Introduction: Adds a table listing each of the 27 building types with brief description.	Adds new table in Introduction section
7-13-2	7/31/13	8/1/13-10/31/13	CFL	**CFL: Savings Estimation Approach** Adds statement that permits usage of actual wattage data (of CFL) and manufacturer's cut data sheet when known, in place of deemed value in Appendix C. Adds method for replacing halogens.	Pgs. 12, 107
7-13-3	7/31/13	8/1/13-10/31/13	Refrigerators	**Refrigerators** Adds and describes 2 options that can be utilized to estimate energy savings due to refrigerator replacement. Description of the metering option is removed. Also adds savings adjustment factors based on age and seal condition of refrigerator being replaced.	Pgs. 16-17
7-13-4	7/31/13	8/1/13-10/31/13	Refrigerator/ Freezer Bounty	**Refrigerator and Freezer Recycling: Annual Energy and Summer Peak Demand Savings** Replaces deemed peak kW savings factor with temperature adjustment and load shape factors.	Pg. 23
7-13-5	7/31/13	8/1/13-10/31/13	Indirect Water Heater (Residential)	**Residential Indirect Water Heater: *Method for Calculating Energy Savings*** Adds title of "Gallons per Day"	Pg. 85
7-13-6	7/31/13	8/1/13-10/31/13	Indirect Water Heater (Residential)	**Residential Indirect Water Heater*: Tank overall heat loss coefficient*** Heat loss coefficient (UA) default values added for typical water heater sizes; 40, 80 & 120 gallons.	Pg. 86
7-13-7	7/31/13	8/1/13-10/31/13	Faucet Aerators	**Faucet Aerators: *Summary of Variables and Data Sources*** Corrects transposition of GPM usage in table.	Pg. 95

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Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
7-13-8	7/31/13	8/1/13-10/31/13	Lighting (Commercial)	**Interior and Exterior Lighting:** ***Method for Calculating Summer Peak Demand and Energy Savings*** Adds/defines baseline conditions for retrofits.	Pgs. 109, 111
7-13-9	7/31/13	8/1/13-10/31/13	Interior Lighting Controls	**Interior Lighting Controls** Adds method and table to calculate full load hours using automatic controls.	Pg. 113
7-13-10	7/31/13	8/1/13-10/31/13	Boilers and Furnaces (Commercial)	**Furnaces and Boilers**: ***Method for Calculating Energy Savings*** Modifies text to define thermal efficiency and how it and combustion efficiency are used for larger boilers and furnaces.	Pgs. 136-137
7-13-11	7/31/13	8/1/13-10/31/13	Boilers and Furnaces (Commercial)	**Furnaces and Boilers**: ***Method for Calculating Energy Savings*** Addition to text defines minimum efficiencies for furnaces and boilers in accordance with New York State Energy Conservation Construction Code	Pgs. 137-138
7-13-12	7/31/13	8/1/13-10/31/13	Variable Frequency Drives	**Variable Frequency Drives:** ***Method for Calculating Summer Peak Demand and Energy Savings*** Corrects incorrect appendix reference (should be Appendix K.)	Pg. 157
7-13-13	7/31/13	8/1/13-10/31/13	Indirect Water Heaters (Commercial)	**Indirect Water Heaters** ***Method for Calculating Energy Savings*** Corrects definition of thermal efficiency and removes unused definitions.	Pg. 165

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RECORD OF REVISION					
Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
7-13-14	7/31/13	8/1/13-10/31/13	Indirect Water Heaters (Commercial)	**Indirect Water Heaters** ***Method for Calculating Energy Savings*** Copies table containing deemed values of water usage from "Water Heaters" section above into this section. Also Corrects UA values table by removing "base" so that resulting table indicates UA values based on diameter and insulation.	Pgs. 166-167
7-13-15	7/31/13	8/1/13-10/31/13	Pipe Insulation	**Pipe Insulation:** Adds entirely new section covering savings in space heating and domestic hot water through installation of pipe insulation.	N/A – New Section
7-13-16	7/31/13	8/1/13-10/31/13	Evaporator Fan Controls	**Evaporator Fan Controls:** ***Savings Estimation Approach*** and ***Summary of Variables and Data Source*** Corrects mislabeled savings factor, $F_{control}$ and corrects formulae for calculating kWh and kW savings.	Pgs. 175-176
7-13-17	7/31/13	8/1/13-10/31/13	ECM's	**ECMs for Refrigerated Cases and Walk In Cooler Fans** Corrected formula for kWh	Pg. 185
7-13-18	7/31/13	8/1/13-10/31/13	Building Prototypes	**Appendix A: Refrigerated Warehouse** Clarifies that the building model applies only to new construction.	Appendix A, pg. 249
7-13-19	7/31/13	8/1/13-10/31/13	Minimum Outdoor Air Fraction	**Appendix A: Hotel:** Defines term "PTAC" and adds "Minimum Outdoor Air Fraction to building characteristics listing; FYL only, term not used in calculation and applies only to portions of building covered by HVAC system.	Appendix A, pg. 235
7-13-20	7/31/13	8/1/13-10/31/13	Building Prototypes	**INTRODUCTION & Appendix A: Commercial Building Prototypes** Clarifies what constitutes "other" and when it should be used.	Pgs. 11, 218 respectively

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Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
7-13-21	7/31/13	8/1/13-10/31/13	Building Prototypes	**Appendix A: Prototypical Building Descriptions** Clarifies definition of "old", "average", and "new" vintage by eliminating gaps in range of year categories.	Appendix A, pg. 209
7-13-22	7/31/13	8/1/13-10/31/13	Weighting Factors for Commercial Buildings	**Appendix B: Weighting Factors for Commercial Building Calculation** Adds weighting factors for HVAC interactive effects for 13 building types and "other."	N/A – Adds new table after low-rise weighting factor table.
7-13-23	7/31/13	8/1/13-10/31/13	Lighting	**Appendix C: Standard Fixture Watts** Adds additional fixtures throughout Appendix C.	Throughout Appendix C, pgs. 254-288
7-13-24	7/31/13	8/1/13-10/31/13	Roof Insulation	**Appendix E: Roof Insulation** Corrects mislabeled item in last NYC table; should read "Gas Heat, No AC."	Appendix E, pg. 319
7-13-25	7/31/13	8/1/13-10/31/13	Air Leakage Sealing and Opaque Shell Insulation	**Appendix E: Opaque Shell Measure Savings** Adds statement at beginning of section that effective 'R' values reflect the factors of compression and installation quality.	Appendix E, pg. 297
7-13-26	7/31/13	8/1/13-10/31/13	Wall and Roof Insulation	**Appendix E:** Adds missing 'R' value column for Binghamton.	Appendix E, pgs. 325-330
7-13-27	7/31/13	8/1/13-10/31/13	Page Header and R Value Correction	**Appendix H: Residential Distribution System Efficiency in Cooling Mode (Attic Ducts)** Corrects page headers which incorrectly identified this section as 'G.' R value corrected in two pages to correctly list values as R-6.	Appendix H, pgs. 437-438
7-13-28	7/31/13	8/1/13-10/31/13	Engine Block Heater Timer	**Engine Block Heater Timer** Adds this agricultural measure.	N/A-New Section
7-13-29	7/31/13	8/1/13-10/31/13	Indirect Residential Water Heaters	Deemed value of 1 inch insulation if thickness of tank insulation not known.	Pg. 98

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7-13-30	7/31/13	8/1/13-10/31/13	Commercial programmable setback thermostats (PSTs)	Default value from table has been removed. Engineering judgment may be required if installing only PST.	Pg. 151
7-13-31	7/31/13	8/1/13-10/31/13	Evaporator fan controls & ECM Motors in refrigerator cases & Walk-In Cooler Fans	Corrects formulae to derive kW value. (Volts x amps must be divided by 1000.)	Pgs. 174, 185
7-13-32	7/31/13	8/1/13-10/31/13	Boilers & Furnaces	Correction of error in formula.	Pgs. 47, 77
7-13-33	7/31/13	8/1/13-10/31/13	Residential Indirect Water Heaters	Missing unit conversion factor corrected.	Pg. 83
7-13-34	7/31/13	8/1/13-10/31/13	Residential (& Commercial) Indirect Water Heaters	Recovery efficiency used to determine UA now listed in residential section; for larger boilers UA is determined by using standby loss specification.	Pgs. 85 & 165
7-13-35	7/31/13	8/1/13-10/31/13	Residential Indirect Water Heaters	Removes reference to electric water heater as baseline unit.	Pg. 85
7-13-36	7/31/13	8/1/13-10/31/13	Water heaters, residential and commercial	Corrects inconsistent unit conversion factor of 100,000 BTU's/therm	Pgs. 78, 159
7-13-37	7/31/13	8/1/13-10/31/13	EFLH for Room Air Conditioners	Manual now lists most current, verified EFHL for Con Ed of 382 hours.	Pgs. 76-77
7-13-38	7/31/13	8/1/13-10/31/13	Opaque Shell Insulation	Identification of peak coincidence factor (CF_s) corrected.	Pg. 26
7-13-39	7/31/13	8/1/13-10/31/13	Chillers	Transitions from use of Coefficient of Performance (COP) to kW/ton for purpose of sizing chillers. Minimum efficiencies listed are least stringent allowed by NYS ECC and provide greater flexibility to PA's.	Pg. 145
7-13-40	7/31/13	8/1/13-10/31/13`	Commercial Indirect Water Heaters	Deemed value of 1 inch insulation if thickness of tank insulation not known	Pg. 98

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Revision Number	**Issue Date**	**Effective Date Range**	**Measure**	**Heading/Subsection of Tech Manual Change or Addition and Brief Description of Change/Addition**	**Location/Page in Tech Manual (October 15, 2010)**
7-13-41	7/31/13	8/1/13-10/31/13	Refrigerators	The inserted footnote describes how the retail rebate measure does not require a chapter, and its analysis can otherwise use materials in this chapter. Rebates at the retail level affect choice between new refrigerators, leaving no existing old one to be recycled or not	Pg. 15
6-13-1	6/30/13	7/1/13 – 9/30/13	Water Heater (Residential)	***Method for Calculating Energy Savings*** Revises the inlet water temperature ('T' mains column) in the accompanying tables for New York City from 62.5^0 to 55^0 (F) **AND** Inserts row for inlet water temperature ('T' mains column) in accompanying tables for Long Island, to acknowledge difference of water source from NYC. Inlet water temperature for Long Island established at 62.5^0(F)	Pg. 80
6-13-2	6/30/13	7/1/13 – 9/30/13	Indirect Water Heater (Residential)	Same as above.	Pg. 85
6-13-3	6/30/13	7/1/13 – 9/30/13	Heat Pump Water Heater (Residential)	Same as above.	Pg. 90
6-13-4	6/30/13	7/1/13 – 9/30/13	Low Flow Showerheads (Residential)	Same as above.	Pg. 93
6-13-5	6/30/13	7/1/13 – 9/30/13	Faucet Aerators (Residential)	Same as above.	Pg. 95
6-13-6	6/30/13	7/1/13 – 9/30/13	Water Heaters (Commercial)	Same as above.	Pg. 161
6-13-7	6/30/13	7/1/13 – 9/30/13	Indirect Water Heater (Commercial)	Same as above.	Pg. 166
6-13-8	6/30/13	7/1/13 – 9/30/13	Low Flow Showerheads (Commercial)	Same as above.	Pg. 171
6-13-9	6/30/13	7/1/13-9/30/13	Faucet Aerators (Commercial)	Same as above.	Pg. 173
3-13-1	3/14/13	3/14/13	Appendix O	C&I Lighting Policy	On DPS Website

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5-11-1	5/6/11	5/6/11	Appendix M	Guidelines for Early Replacement Conditions	On DPS Website
Original Issue	10/15/10	1/1/11	Original Issue	Original Issue	Original Issue

MULTIFAMILY RESIDENTIAL MEASURES

Building shell

<u>Window and Through-the-Wall Air Conditioner Cover & Gap sealer</u>

Description of Measure

A rigid, insulated cover installed on the inside of a window or through-the-wall room air conditioning (RAC) unit. It covers and seals the AC unit and the gap surrounding the unit. The cover is designed for RAC units left in place throughout the heating season; covers must be installed and maintained by building facility's staff.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

$\Delta therm = units \times [(1.08 \times CFM \text{ x } HDD \times 24hrs/day)/Boiler\ Efficiency)]/100{,}000$

where:

Δtherm	= gross annual gas savings
units	= the number of units installed
1.08	= specific heat of air × density of inlet air @ 70^{o}F × 60 min/hr
CFM	= air flow measured in cubic feet per minute
HDD	= heating degree days
100,000	= BTU to therm conversion

Annual Deemed Savings

Annual Deemed Energy Savings Values (therms), for New York City	
Low-End Estimate at 5 Pa* Indoor-Outdoor Pressure Differential	High-End Estimate at 10 Pa* Indoor-Outdoor Pressure Differential
23	32

*** Note**: Pa= Pascal, the standard unit of pressure or stress in the International System of Units (SI.) If indoor-outdoor pressure differential is not known, use the rounded average of 28 therms.

Summary of Variables and Data Sources (for informational purposes)

Variable	Value	Notes
Heating plant seasonal efficiency	0.70	This value used in Urban Green Building Council study.
HDD	6,343	Albany Climate
HDD	6,954	Binghamton Climate
HDD	6,360	Buffalo Climate
HDD	7,738	Massena Climate
HDD	4,500	NYC Climate
HDD	5,781	Poughkeepsie Climate
HDD	6,301	Syracuse Climate
CFM low end	13	Field tested leakage at 5 Pa indoor-outdoor differential pressure

Coincidence Factor (CF)
The recommended value for the coincidence factor is – N/A

Baseline Efficiencies from which Savings are Calculated – N/A

Compliance Efficiency from which Incentives are Calculated – N/A

Operating Hours – N/A

Ancillary Fossil Fuel Savings Impacts – N/A

Ancillary Electric Savings Impacts – N/A

Effective Useful Life (EUL)
Years: 5 years
Source: At least one known manufacturer's warranty period.

References

1. *There Are Holes in Our Walls*; A Report Prepared for the Urban Green Building Council, by Steven Winter Associates, April 2011.

Record of Revision

Version Number	Record of Revision Number	Record of Revision Issue Date
0	6-14-1	6/19/14

SINGLE and MULTIFAMILY RESIDENTIAL MEASURES

Domestic Hot Water - Control

Thermostatic Shower Restriction Valve

Description of Measure
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^{o}F, or slightly lower, depending on manufacturer.

Method for Calculating Annual Energy and Peak Coincident Demand Savings
The general algorithm for shower adapter is:

Number of Units × Savings per Unit

Deemed Savings Table

Natural Gas

GPM Flow Rate	1.5	1.75	2.0	2.25	2.5
Therm Savings					
Albany	6.2	7.3	8.3	9.3	10.4
Binghamton	6.4	7.4	8.5	9.6	10.6
Buffalo	6.2	7.2	8.3	9.3	10.3
Massena	6.6	7.8	8.9	10.0	11.1
Syracuse	6.2	7.2	8.2	9.3	10.3
Upstate Avg	6.3	7.4	8.4	9.5	10.5
Long Island	5.2	6.1	6.9	7.8	8.7
NYC	5.2	6.1	6.9	7.8	8.7
Electric					
kWh Savings					
Albany	141	164	188	211	235
Binghamton	144	169	193	217	241
Buffalo	141	164	187	211	234
Massena	151	176	201	226	251
Syracuse	140	163	186	210	233
Upstate Avg	143	167	191	215	239
Long Island	118	137	157	177	196
NYC	118	137	157	177	196

Summary of Variables and Data Sources (for informational purposes)

Variable	Value	Notes
KWh savings		Look up based on location and water usage rate
Therm savings		Look up based on location and water usage rate
GPM_{ee}		From application
GPM_{base} (New York City)	2.0[1]	Per 2012 update to NYC Plumbing Code (table 604.4)
GPM_{base} (All other New York State areas)	2.5	Per NYS Energy Conservation Law, subsection 15-0314
Throttle factor	0.75	
Behavioral Waste Time	Average value of 1.67 min. (1 min., 40 seconds.)	Calculated from total water waste percentage of 30%, from Abstract of reference listed below.
Showers/day	2	
T_{shower}	105	
T_{mains}		Avg T_{mains}
Water heater efficiency	0.97	Electric
	0.75	Gas

Inlet Water Temperature Factors (Same table used for all DHW measures.)

City	Annual average outdoor temperature (°F)	T mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate Average	47.3	53.3
Long Island	56.5	62.5
NYC	56.5	55.0

Coincidence Factor (CF)
The recommended value for the coincidence factor Is – N/A

Baseline Efficiencies from which Savings are Calculated – N/A

Compliance Efficiency from which Incentives are Calculated – N/A

Operating Hours – N/A

[1] Use the default values unless other showerhead flow rate is known.

Ancillary Fossil Fuel Savings Impacts – N/A

Ancillary Electric Savings Impacts – N/A

Effective Useful Life (EUL)
Years: 10years
Source: n/a

References

1. Water and Energy Wasted During Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems, Jim Lutz, Lawrence Berkeley National Laboratory, September 2011; LBNL-5115E

Record of Revision

Version Number	Record of Revision Number	Record of Revision Issue Date
0	6-14-2	6/19/14

APPENDIX A. PROTOTYPICAL BUILDING DESCRIPTIONS

Multi-family Low-Rise

The low-rise prototype “model” in fact contains 2 separate buildings. Each version of the buildings are 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:

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 Code (if applicable.) This vintage is referred to as “From 2007 through the present.”

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 varies 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 setpoints	1. Heating: 70^0F with setback to 67^0F(other than NYC); 73^0F with setback to 70^0F (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 duct work.
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 setpoint 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(when built)	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 (Climate zones 4 & 5) 49 (Climate zone 6)	Code

Thermostatic Heating Setpoint Assumptions by Vintage

Vintage	Setpoint 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-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	
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%

Characteristic	Value
Thermostat setpoints	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 (Climate zones 4 & 5) -49 (Climate zone 6)	Code

Thermostatic Heating Set point Assumptions by Vintage

Vintage	Setpoint 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-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.

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APPENDIX G. HEATING AND COOLING EQUIVALENT FULL-LOAD HOURS

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)[2] 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] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

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 Code (if applicable.) This vintage is referred to as "From 2007 through the present."

Heating equivalent full load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical residential buildings. The prototype building characteristics are described in Appendix A. The heating EFLH for the vintages and six different cities in NY are shown below:

Multifamily Low-Rise Cooling Equivalent full load hours 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

* 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 (AC) within the unit. See the section in this manual pertaining to room AC units and how savings are calculated.

Multifamily High-Rise Cooling Equivalent full load hours by Vintage and City*

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

* 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 (AC) within the unit. See the section in this manual pertaining to room AC units and how savings are calculated.

Multifamily Low-Rise Heating Equivalent full load hours 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*	999	757	723	503
Poughkeepsie	857	894	868	616
Syracuse	1,395	1,175	1,206	845

* NYC building only incorporates a higher thermostatic set point of 73^0 F instead of 70^0 F based on reported data.[3] The other cities listed use the thermostatic set point of 70^0 F.

Multifamily High-Rise Heating Equivalent full load hours 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*	1,012	526	395	219
Poughkeepsie	922	656	510	291
Syracuse	1,063	889	787	474

* NYC building only incorporates a higher thermostatic set point of 73^0 F instead of 70^0 F based on reported data.[4] The other cities listed use the thermostatic set point of 70^0 F.

[3] Overheating in Hot Water and Steam-Heated Multifamily Buildings, U.S. Dept. of Energy, Jordan Dentz, Kapil Varshney and Hugh Henderson, October 2013.

[4] Ibid

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Table 3-14-3 (A)

Previous name/vintage	**Revised name/vintage**
N/A	Pre-war uninsulated brick
Older, poorly insulated	Prior to 1979
Existing, average insulation	From 1979 through 2006
New construction	From 2007 through the present

Energy Star® Dehumidifier

Description of Measure

Residential stand-alone or whole-house dehumidifiers meeting the minimum qualifying efficiency standards established under the Energy Star® Program, Version 3.0[5]

Method for Calculating Energy and Savings Summer Peak Demand

The general algorithm for an Energy Star dehumidifier is:

ΔkWh Savings = *Savings per Unit as described below:*

Electricity savings for capacities of typical Energy Star® Dehumidifiers are shown below. Savings for capacities not listed should be determined using the Savings Calculator for Energy Star® Qualified Appliances. (See Note/Reference number 2 on next page.)

Version 3.0

Energy Star Dehumidifier Savings	
pints/day	kWh savings
25	161
28	180
30	193
35	225
40	162
45	183
50	136
60	92
65	100
70	107
90	124
105	145
108	149
109	150
110	152
120	165
155	214
184	254

Peak demand savings:

ΔkW_s = units x 0.0098 × CF

where:

ΔkW_s = gross peak demand savings

units = total number units

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[5] Energy Star® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 3.0

0.0098[6] = unit peak demand reduction
CF = demand coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh savings		Lookup based on capacity (pints per day)
Capacity (pints/day)		From application
ΔkW_S demand savings	0.0098	Note[2]
Coincidence Factor (CF)	1.0	Note[7]

The *Energy Star® Dehumidifier Calculator* is used to create the energy savings tables.

Coincidence Factor (CF)
The demand coincidence factor is used to account for the fact that not all HVAC systems in all buildings in the population are operating at full nameplate capacity at the time of the system peak. The coincidence factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of system peak.

Baseline Efficiencies from which Savings are Calculated
Energy Star® program requirements product specification for dehumidifiers Performance Criteria[8], Version 3.0, are shown in the table below.

Efficiency Standard for Dehumidifiers

Federal Standard		ENERGY STAR V 3.0	
Product Capacity (pints/day)	Minimum energy factor (liters/kWh)	Product Capacity (pints/day)	Minimum energy factor (liters/kWh)
≤35	1.35	<75	1.85
>35 to ≤45	1.50		
>45 to ≤54	1.60		
>54 to ≤75	1.70		
≥75	2.50	≥75 to ≤185	2.80

Notes & References

1. Federal Standard (L/kWh) for residential dehumidifiers, http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/55#standards
2. Savings Calculator for Energy Star® Qualified Appliances. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/appliance_calculator.xlsx

[6] Demand savings from Energy-Efficiency and DSM Rules for Pennsylvania's Alternative Energy Portfolio Standard Technical Reference Manual, September 7, 2005.

[7] Coincidence factor is embedded in summer peak demand reduction estimate.

[8] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 3.0. http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dehumid/ES_Dehumidifiers_Final_V3.0_Eligibility_Criteria.pdf?3cbf-7a48;

3. Energy Star® dehumidifier performance criteria , http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dehumid/ES_Dehumidifiers_Final_V3.0_Eligibility_Criteria.pdf?5cc6-443c

Revision Number

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Water Heater

Description of Measure

Efficient instantaneous and storage type water heaters installed in whole-house applications.

Method for Calculating Energy Savings

$$\Delta kW_S = units \times \frac{(UA_{base} - UA_{ee}) \times \Delta T_s}{3413} \times DF_s \times CF_s$$

$$\Delta kWh = \; = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{3413} \times \left[\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right]$$

$$\Delta therm = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{100,000} \times \left[\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right]$$

where:

ΔkW_s = gross coincident demand savings

ΔkWh = gross annual energy savings

$\Delta therm$ = gross annual gas savings

units = number of high efficiency water heaters installed under the program

UA_{base} = overall heat loss coefficient of base water heater (Btu/hr-°F)

UA_{ee} = overall heat loss coefficient of efficient water heater (Btu/hr-°F)

ΔT_s = temperature difference between the stored hot water and the surrounding air (°F)

GPD = average daily water consumption (gallons/day)

$\overline{\Delta T}_w$ = average difference between the cold inlet temperature and the hot water delivery temperature (°F)

EF_{base} = baseline water heater energy factor

EF_{ee} = efficient water heater energy factor

DF = demand diversity factor

CF	= coincidence factor
3413	= conversion factor (Btu/kWh)
8.33	= conversion factor (Btu/gallon-°F)
100,000	= conversion factor (Btu/therm)
365	= conversion factor (days/yr)

Tank overall heat loss coefficient (UA[9]) is used to calculate the summer peak savings, which are assumed to be caused by reductions in standby losses. The UA is calculated from the energy factor, recovery efficiency, and heater electric element or gas burner capacity:

$$UA = \frac{\frac{1}{EF} - \frac{1}{RE}}{67.5 \times \left(0.000584 - \frac{1}{RE \times Cap}\right)}$$

RE_{base} = recovery efficiency
Cap_{base} = water heater capacity (Btu/hr)

Standard assumptions for recovery efficiency and input capacity for non-condensing water heaters[10] are:

Water Heater Type	Recovery efficiency	Capacity (Btu/hr)
Electric	0.97	15,400
Gas	0.75	40,000

Tankless water heaters have no standby losses, thus the tank UA_{ee} for a tankless water heater should be set to 0.0.

The ***coincidence factor*** is used to account for the fact that not all water heaters in all buildings in the population are operating at full nameplate capacity at the time of the system peak. The coincidence factor is defined as the average fraction of installed capacity of a population of water heaters that are operating at the time of system peak.

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

[9]U-value is a commonly used term for the overall heat loss coefficient, in Btu/hr-SF-F. UA incorporates surface area, and has the units of Btu/hr-F.

[10] Values applicable to non-condensing water heaters with EF ≤ 0.68.

The baseline energy factor (EF_{base}) is as follows:

New construction and replace on failure: efficient water heater is assumed to replace a standard efficiency tank-type water heater. Energy Factors (EF) according to NAECA for storage water heaters are calculated as a function of storage volume:

Electric water heaters: EF = 0.97-0.00132V
Gas water heaters: EF = 0.67-0.0019V
where V is tank volume in gallons.

Compliance Efficiency from which Incentives are Calculated

ACEEE recommendations for the energy factor (EF_{ee}) of storage type water heaters are as follows:

Electric: EF $\geq$ .93

Gas: EF $\geq$ .67

ACEEE recommendation for the energy factor (EF_{ee}) of tankless water heaters is as follows:

Gas: EF > .8

Operating Hours

Water heater assumed to be available at all hours.

Non-Electric Benefits - Annual Fossil Fuel Savings

Reduction in standby heat losses will have some impact on space heating and cooling when water heater located in conditioned space. These are considered small and not included in these calculations.

Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		Calculated from EF and RE
UA_{ee}		Calculated from EF and RE
delta T_s	Tset - Tamb	
GPD	78	Default for SF. Use GPD based on number of units for MF.
delta T_w	Tset - Tmain	
EF_{base}		Calc from tank volume and fuel type
EF_{ee}		From application

Tank volume		From application
T_{set}	130	
T_{amb}	65	
T_{mains}		Avg T_{mains} based on upstate or downstate
	15,400	Electric (Default for SF and single unit MF, use application for central MF)
Capacity	40,000	Gas (Default for SF and single unit MF, use application for central MF)
	0.97	Electric
RE	0.75	Gas
CF_s	1	

Indirect Water Heaters

Indirect water heaters are tank-type water heaters that are indirectly heated by hot water from a boiler rather than direct input from electric elements or gas burners. A heat exchanger separates the potable water in the water heater from the boiler water. The baseline assumption for indirect water heaters is a standard efficiency tank type water heater or an indirect system with a standard efficiency boiler.

<u>Method for Calculating Energy Savings</u>

$$\Delta\text{therm} = units \times \left[\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{100{,}000} \times \left[\frac{1}{E_{t,base}} - \frac{1}{E_{t,ee}} \right] + \left(\frac{UA_{base}}{E_{t,base}} - \frac{UA_{ee}}{E_{t,ee}}\right) \times \frac{\Delta T_s}{100{,}000} \times 8760 \right]$$

$$UA_{base} = \frac{\dfrac{1}{EF_{base}} - \dfrac{1}{RE_{base}}}{67.5 \times \left(0.000584 - \dfrac{1}{RE_{base} \times Cap_{base}}\right)}$$

$$EF_{base} = 0.67 - 0.0019 V_{base}$$

where:

Δtherm	= gross annual gas savings
units	= number of high efficiency water heaters installed under the program
UA_{base}	= overall heat loss coefficient of base tank type water heater (Btu/hr-°F)
UA_{ee}	= overall heat loss coefficient of indirect water heater storage tank (Btu/hr-°F)
ΔT_s	= temperature difference between the stored hot water and the surrounding air (°F)
GPD	= average daily water consumption (gallons/day)

$\overline{\Delta T}_w$ = average difference between the cold inlet temperature and the hot water delivery temperature (°F)
EF_{base} = baseline storage water heater energy factor
$E_{c,ee}$ = energy efficient indirect water heater boiler combustion efficiency
$E_{c,base}$ = baseline water heater efficiency (=RE_{base} if tank type baseline; $E_{c,base}$ if indirect baseline)
RE_{base} = tank type water heater recovery efficiency
Cap_{base} = tank type water heater capacity (Btu/hr)
V_{base} = tank type water heater capacity (gallons)
8.33 = conversion factor (Btu/gallon-°F)
r_1 = radius of bare tank (ft)
r_2 = radius of tank plus existing insulation (ft)
r_3 = radius of tank plus existing insulation plus additional insulation (ft)
H = height of tank (ft)
th_{bot} = thickness of insulation on tank bottom (ft)
th_{top} = thickness of insulation on tank top (ft)
th_{wrap} = thickness of tank wrap (ft)

UA values for typical indirect water heater tanks are shown below.

Volume (gal)	H (bare tank) inches	Diameter (bare tank) inches	Insulation	UA (Btu/hr-degF)
40	44	17	1 in foam	4.1
			2 in foam	2.1
80	44	24	1 in foam	6.1
			2 in foam	3.1
120	65	24	1 in foam	8.4
			2 in foam	5.4

The ***coincidence factor*** is used to account for the fact that not all water heaters in all buildings in the population are operating at full nameplate capacity at the time of the system peak. The coincidence factor is defined as the average fraction of installed capacity of a population of water heaters that are operating at the time of system peak.

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline energy factor (EF_{base}) is as follows:

New construction and replace on failure: The efficient water heater is assumed to replace a standard efficiency tank-type water heater. Energy Factors (EF) according to NAECA for storage water heaters are calculated as a function of storage volume:

Electric water heaters: EF = 0.97-0.00132V
Gas water heaters: EF = 0.67-0.0019V

where V is tank volume in gallons.

Heat Pump Water Heater

Measure Description
An electric heat pump water heater is a domestic water heater that uses heat pump technology to move heat from the air (inside or outside the home) to the water storage tank. The heat pump is similar to a standard air conditioner, but instead of exhausting the heat to the outside of the home and putting the cooled air into the home, the heat pump water heater places the heat from the air into the water that is then stored in the hot water tank. The cooled air is exhausted into the home (for interior installed units) or can be vented outside of the home. If the cooled air is exhausted into the home it can affect the energy consumption of the home's heating and cooling system. A water heat pump can lower the amount of air conditioning required. During cooler months, additional heating is required for the home to offset the cold air from the water heater unless the chilled air is vented to the outside of the home. Savings calculation approaches need to consider the energy impacts to both the domestic water heating system and to the home in which the units are installed to estimate the energy impacts on the home (rather than just the hot water supply). Impacts for both electric and non-electric energy consumption need to be reported for programs that include systems that vent cooled air into the home.

<u>Method for Calculating Energy Savings</u>

ΔkW_S = 0.5

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T}}{3413} \times \left[\frac{1}{EF_{base}} - \frac{1}{EF_{ee}} \right]$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= number of high efficiency water heaters installed under the program
GPD	= average daily water consumption (gallons/day)
$\overline{\Delta T}_w$	= average difference between the cold inlet temperature and

the hot water delivery temperature (°F)

EF_{base} = baseline water heater energy factor

EF_{ee} = efficient water heater energy factor

3413 = conversion factor (Btu/kWh)

8.33 = conversion factor (Btu/gallon-°F)

365 = conversion factor (days/yr)

New construction and replace on failure: The efficient water heater is assumed to replace a standard efficiency tank-type water heater. Energy Factors (EF) according to NAECA for storage water heaters are calculated as a function of storage volume:

Electric water heaters: EF = 0.97-0.00132V
Gas water heaters: EF = 0.67-0.0019V

Where: V is tank volume in gallons.

Compliance Efficiency from which Incentives are Calculated

Average energy factor for heat pump water heaters is 2.2.

Operating Hours

Water heater assumed to be available at all hours.

Non-Electric Benefits - Annual Fossil Fuel Savings

Heat pump water heaters installed in heated spaces will impact the space heating load.

Summary of Variables and Data Sources

Variable	Value	Notes
GPD	78	Family of 4
delta T	T_{set} - T_{main}	
EF_{base}		Calc from tank volume
EF_{ee}	2.2	
Tank volume		From application
T_{set}	130	
T_{amb}	65	

Notes & References

1. Average hot water use per person taken from: Lutz, James D., Liu, Xiaomin, McMahon, James E., Dunham, Camilla, Shown, Leslie J.McCure, Quandra T; “Modeling patterns of hot water use in households;” LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996..

2. Average annual outdoor temperature taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE-2.2 weather data statistics package. www.nrel.gov
3. 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.

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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	1279	1024	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	1279	1024	831
Light Industrial	400	435	423	370	549	475	429
Motel	734	959	1084	997	1233	1143	1072
Primary School	297	264	244	257	394	346	274
Religious Worship	227	1006	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	Bing-hamton	Buffalo	Massena	NYC	Pough-keepsie	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*	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
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

*** 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.**

Small Commercial Heating EFLH

Building	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Assembly	961	1006	990	1158	603	782	903
Auto Repair	3325	3455	3331	3649	1910	2642	3271
Big Box Retail	554	509	557	620	191	373	522
Fast Food Restaurant	1426	1526	1491	1690	813	1120	1351
Full Service Restaurant	1502	1602	1567	1746	821	1162	1419
Grocery	554	509	557	620	191	373	522
Light Industrial	1278	1320	1188	1286	714	996	1200
Motel	1037	787	789	832	619	603	778
Primary School	1300	1290	1357	1311	840	1070	1236
Religious Worship	954	202	978	1015	722	802	962
Small Office	747	793	760	861	431	589	750
Small Retail	984	1006	1020	1134	545	765	969
Warehouse	916	1023	940	1094	452	642	888
Other	1195	1156	1194	1309	681	917	1136

Large Commercial Heating EFLH

Building	System	Albany	Bing-hamton	Buffalo	Massena	NYC	Pough-keepsie	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
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

*** 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.**

Refrigerator[11] Rebates

This section pertains to the calculation of energy savings for refrigerator retail rebate programs. The savings are calculated by taking the difference between the energy consumption of the Tier 2 or Tier 3[12] model purchased and the consumption of the Department of Energy (DOE) minimally compliant model most closely associated with the new refrigerator in features/design (e.g., top freezer.) The energy savings are computed for the entire Effective Useful Life (EUL) of the new refrigerator which is currently set at 17 years.[13] The calculations are shown below:

Annual Energy and Peak Demand Savings

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

$$\Delta kW_S = \left\{ \frac{kWh_{DOE\ min}}{8{,}760} - \frac{kWh_{ee}}{8{,}760} \right\} \times CF \times (1 + HVAC_d)$$

$$\Delta therm = \Delta kWh \times HVAC_g$$

where:

ΔkWh	= gross annual energy savings
ΔkWs	= gross coincident demand savings
$\Delta therm$	= gross annual gas impacts from heating system interactions
$kWh_{DOE\ min}$	= annual energy consumption of DOE minimally-compliant model most closely associated with the new refrigerator[14]
kWh_{ee}	= annual energy consumption/nameplate rating for the new CEE Tier 2 or Tier 3 model
CF	= coincidence factor (1.0)
$HVAC_c$	= HVAC system interaction factor for annual energy consumption
$HVAC_d$	= HVAC system interaction factor at utility peak hour
$HVAC_g$	= HVAC system interaction factor for annual gas consumption
8760	= conversion factor (hr/yr)
F_{occ}	= occupant adjustment factor

[11] This section applies to refrigerators with and without freezers

[12] Tiers 2 and 3 are efficiency rating established by the Consortium for Energy Efficiency (CEE.) The ratings are located at: http://library.cee1.org/content/qualifying-product-lists-residential-refrigerators

[13] Order Approving Modifications to the Technical Manual, Issued July 18, 2011, Appendix, page 2.

[14] The Energy Star website referenced here lists the energy consumption of the Energy Star model compared with the energy consumption of the DOE minimally-compliant model which is the number used in this calculation. http://www.energystar.gov/productfinder/product/certified-residential-refrigerators/results?scrollTo=2373&search_text=&sort_by=less_energy_than_us_federal_standard&brand_name_isopen=&page_number=3&lastpage=1

Occupant Adjustment Factor

The occupant adjustment factor[15] is used to adjust the energy savings according to the number of occupants in the apartment (if applicable), as shown in the following table:

Number of Occupants	F_{occ}
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

Operating Hours

The equations above assume the refrigerator is operating year-round. The cycling of the compressor is considered in the annual energy consumption and compressor duty cycle run time.

HVAC Interactions

Efficient refrigerators reject less heat into the conditioned space, which must be made up by the space heating system, but can also provide savings on cooling loads. Calculations must include space heating interactions with efficient refrigerators. 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.

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[15] The occupant adjustment factor is taken from National Energy Audit Tool (NEAT). Oak Ridge National Laboratory, Oak Ridge, TN.

Refrigerator and Freezer Recycling

Description of Measure

The savings calculations apply to recycling of a functioning primary[16] or secondary refrigerator or freezer.

Annual Energy and Summer Peak Demand Savings

The following deemed energy impact estimates shall be used in New York for refrigerator and freezer recycling programs[17].

Energy savings per unit:

Primary Refrigerators:	670 kWh[18]
Secondary Refrigerators:	1,655 kWh
Freezers:	1,257 kWhs

Peak demand savings per unit:

$\Delta kW_S = \Delta kWh / 8760 \times TAF \times LSAF$

TAF = Temperature Adjustment Factor
= 1.22 Upstate
= 1.26 NYC

LSAF = Load Shape Adjustment Factor
= 1.06

Notes & References

1. Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Program, April 2008, ADM Associates.
2. TAF and LSAF taken from 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.

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

[17] See table 2-6 in the Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Program, April 2008, ADM Associates.

[18] Primary Refrigerators: An Examination of Appliance Recycling Program Design; Kate Bushman and Joshua Keeling – Cadmus Group, Inc. and Karen Kansfield, Ameren Illinois, April, 2013.

Weighting Factors for Commercial Building Calculations

The Tech Manual 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: (Note: Some types do not add up to exactly 1.00 due to rounding.)

System Type Weights Small Commercial Building HVAC Systems from CBECS

Building Type	AC with gas heat	Heat Pump	AC with elec 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

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

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Furnace and Boilers (pg. 137)

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency ($\bar{\eta}_{base}$) is defined by the 2010 Energy Conservation Construction Code of New York State (ECCNYS) as follows:

Equipment Type	Size Range	Minimum Efficiency
Furnace	< 225 kBtu/hr	78% AFUE or 80% Et
	> = 225 kBtu/hr	80% Et
Hot Water Boilers	< 300 kBtu/hr	80% AFUE
	>= 300 – 2500 kBtu/hr	75% Et and 80%Ec
	> 2500 kBtu/hr	80% Ec
Steam Boilers	< 300 kBtu/hr	75% AFUE
	>= 300 – 2500 kBtu/hr	75% Et and 80% Ec
	> 2500 kBtu/hr	80% Ec

Record of Revision Number 8-13-2

a. Boilers – Residential (pg. 47)

Compliance Efficiency from which Incentives are Calculated (Recommended)

Efficient boiler efficiency ($\bar{\eta}_{ee}$) is the manufacturer's nameplate efficiency for the installed boiler. The recommended minimum boiler efficiency for incentives is defined as follows:

Boiler Type	Size Range	Recommended Minimum Efficiency
Non-Condensing Hot Water Boilers	< 300 kBtu/hr	85% AFUE
	>= 300 – 2500 kBtu/hr	85% Et or 88% Ec
	> 2500 kBtu/hr	88% Ec
Condensing Hot Water Boilers	< 300 kBtu/hr	90% AFUE
	>= 300 – 2500 kBtu/hr	90% Et or 93% Ec
	> 2500 kBtu/hr	93% Ec
Steam Boilers	< 300 kBtu/hr	82% AFUE
	>= 300 – 2500 kBtu/hr	80% Et or 83% Ec
	> 2500 kBtu/hr	83% Ec

Building Types

Many of the sections that follow provide savings data by building type. A description of each building type is shown below; additional details are shown in Appendix A. Note: the building type classifications are defined primarily by activity, HVAC system type, and number of floors since the deemed parameters in the Tech Manual 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 deg 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
Secondary School	9-12 school
Single Family residential	Single family detached residences

Building Type	*Description*
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.

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Because the light bulbs are purchased from many product sources (drug stores, supermarkets, hardware stores, discount stores, etc.), and by many people, it is not practical to obtain information directly from consumers about the wattage of the baseline bulb (what is being replaced or what would have been used instead of the CFL). The alternative approach is to use a method that avoids the need to determine the baseline for each recorded CFL by assuming that the CFL bulb purchased is the equivalent of the bulb being replaced in terms of light output equivalency. The method is to assume that the baseline is either an incandescent or a halogen bulb as appropriate.

For incandescents assume that the wattage is 3.53 times higher than the wattage of the equivalent CFL bulb. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

Δ Watts = 2.53 x CFL wattage. This is based on an incandescent to CFL wattage ratio of 3.53 to 1. The incandescent equivalency ratio is based on the 2008 DEER update study.

For halogens assume that the wattage is 2.55 times higher than the wattage of the equivalent CFL bulb. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

Δ Watts = 1.55 x CFL wattage. This is based on a halogen to CFL wattage ratio or 2.55 to 1.

Description of Measure

This section covers energy-efficient lighting equipment, such as energy-efficiency lamps, energy-efficiency ballasts, compact fluorescent lamps, LED lamps, and improved lighting fixtures. Energy-efficient lamps may include fluorescent lamps, LED lamps, HID lamps, and incandescent lamps. 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.

$\mathbf{Watts_{base}}$ is defined as the fixture wattage of the baseline lighting fixture. 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. See table of standard fixture wattages in Appendix C.

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.

Record of Revision Number 7-13-3

Refrigerators[19]

This section covers replacement of refrigerators with Energy Star models in single family and multi-family dwellings. High-efficiency refrigerators save energy and demand through improved compressor design, better case insulation, improved door seals, and improvements to defrost and anti-sweat heater controls. Both early replacement and normal replacements are covered in this section. The algorithms include an adjustment for the fraction of replaced refrigerators that enter the used appliance market. Programs that cannot demonstrate disabling or recycling of removed refrigerators should include this adjustment.

Through early replacement, annual savings ranging from a low of 300 kWh per unit, to a high of about 700 kWh per unit are expected. Three options for estimating the annual consumption of a refrigerator being replaced early are provided.[20] The first is measuring/metering actual energy usage of the refrigerator(s) to be replaced. The second option is a nameplate approach, with adjustments for age and condition (where nameplate data are available). The third is use of conservative deemed, default estimates of baseline (existing) refrigerator consumption.

The approach for estimating savings for normal replacements relies on Federal Appliance (NAECA) Standards for establishing baseline energy consumption. The baseline consumption for a normal replacement is a refrigerator or freezer that is minimally compliant with NAECA Standards according to the size and features of the new (replacement) unit.

Eligibility and energy consumption measurement rules for refrigerator replacements are as follows:

1. Only replacement of refrigerators that are ten years old or older are eligible for savings claims.

[19] This section applies to refrigerators with and without freezers

[20] See Order Approving Modifications to the Technical Manual, Case 07-M-0548, July 18, 2011, pps. 18 – 20. In a unique provision to facilitate PA benefit cost analysis, the order provides a $75 default incremental cost for normal replacement of multifamily refrigerators, allowing use of a lesser value, not less than $35, if documented. Although refrigerators in single family homes tend to be larger than those in multifamily housing, $75 may still be used as the incremental cost for normal replacement.

2. Replacement of units from 10 to 16 years old will be treated as ***early replacements*** and initially given full savings relative to the existing unit as calculated using one of the three options.
3. Replacement of older units will be considered ***normal replacements*** and will be given incremental savings. Incremental savings are defined as the difference between the annual kWh consumption of a new unit that is minimally compliant with Federal appliance standards (NAECA) and the new Energy Star unit.

Early Replacement Baseline Refrigerator Energy Consumption

For the nameplate option, the formula is:

$kWh_{base} = kWh_{nameplate} \times F_{age} \times F_{seal}$

where:

$kWh_{nameplate}$	= Nameplate kWh consumption from DOE test procedure
F_{age}	= Nameplate adjustment due to refrigerator age
F_{seal}	= Nameplate adjustment due to seal condition

The age adjustment factor is 1.0 for refrigerators that are nine years old or newer, 1.1 for refrigerators between 9 and 14 years old, and 1.15 for refrigerators older than 14 years old. The seal adjustment factor is 1.0 for intact seals, and 1.05 for deteriorated seals.

The following default values may be used when a PA is unable, or prefers not, to use the metering or nameplate options:

$\boldsymbol{kWh_{base}}$	= 695 kWh/year (ConEd and O&R)
	= 595 kWh/year (All other service territories)

The other options are likely to estimate higher consumption levels. The deemed values are for a relatively small (15 cubic feet) and only ten-year-old refrigerator in a small household.

Notes & References

1. The Energy Star website has a directory of Energy Star qualified refrigerators by make and model number. The directory also lists the baseline energy consumption according to NAECA standards for the size and type of refrigerator purchased. See www.energystar.gov.
2. The age, seal condition and occupant adjustment factors are taken from National Energy Audit Tool (NEAT). Oak Ridge National Laboratory, Oak Ridge, TN. http://weatherization.ornl.gov/national_energy_audit.htm
3. Mean life for normal sized refrigerators is assumed to be 17 years. See Preliminary Technical Support Document: Energy Efficiency Program for Consumer Products: Refrigerators, Refrigerator-Freezers, and Freezers. U.S. Department of Energy, November 2009.

Refrigerator and Freezer Recycling

Description of Measure

Existing, functional refrigerators or freezers replaced by homeowners often continue to be used as a second refrigerator or freezer, or sold or donated for use elsewhere. Refrigerator and freezer recycling programs (also called “bounty” programs) receive energy savings credit for permanently removing existing, functional refrigerators and freezers from the grid. The savings calculations apply to recycling of a functioning primary[21] or secondary refrigerator.

Peak demand savings per unit:

$\Delta kW_S = \Delta kWh / 8760 \times TAF \times LSAF$

TAF = Temperature Adjustment Factor
= 1.22 Upstate
= 1.26 NYC
LSAF = Load Shape Adjustment Factor
= 1.06

Notes & References

1. Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Program, April 2008, ADM Associates.
2. TAF and LSAF taken from 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.

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

Record of Revision Number 7-13-5

Indirect Water Heaters

Gallons per day. Hot water use varies by family size. Estimates of hot water use per person as a function of number of people in the home is shown below.

Number of people	Gal/person-day	Gal/day-household
1	29.4	29
2	22.8	46
3	20.6	62
4	19.5	78
5	18.9	94
6	18.5	111

The ***energy factor*** is used to calculate seasonal water heater efficiency. The energy factor is reported by manufacturers according to a standard test procedure. The energy factor takes into account the efficiency of the heat source (electricity or gas) and the effectiveness of the tank insulation in reducing standby losses.

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Using the default values above, the tank UA for typical gas water heaters are shown in the Table below:

Water Heater Size	Gas Water Heater Tank UA
40	13.6
80	21.6
120	32.8

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<u>Summary of Variables and Data Sources</u>

Variable	Value	Notes
GPM_{ee}	1.5	
GPM_{base}	2.2	
Duration (minutes)	0.5	
Uses/day	30	
Days per year	365	
T_{faucet}	80	
T_{mains}		Avg T_{mains} based on upstate or downstate
Water heater effic.	0.97	Electric
	0.75	Gas

$Watts_{ee}$ is defined as the fixture wattage of the efficient lighting fixture. See table of standard fixture wattages in Appendix C. Manufacturers' cut sheet data for fixture watts can be substituted for the typical values in Appendix C if available.

$Watts_{base}$ is defined as the fixture wattage of the baseline lighting fixture. 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. See table of standard fixture wattages in Appendix C.

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:

Baseline Efficiencies from which Savings are Calculated

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. 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.

Record of Revision Number 7-13-9

Interior Lighting Controls

Description of Measure

This section covers lighting control measures, including occupancy sensors, photocell controls, time clocks, stepped and dimming day lighting controls, dimmers and programmable control systems. 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.

The baseline ***full-load hours*** are the average operating hours for all fixtures subject to lighting control measures ***before the lighting controls are installed.*** Full-load hours for a variety of commercial and residential buildings are discussed in the lighting efficiency section above. The measure full-load hours can be entered directly if known, or calculated from:

$FLH_{ee} = FLH_{base} \times (1 - ESF)$

Where:

ESF = energy savings factor

Energy Savings Factors for Various Automatic Control Options

Control Type	ESF
Occupancy sensor	0.30
Programmable control	0.15
Daylight dimming control	0.30
Daylight stepped control	0.20

Record of Revision Number 7-13-10

Furnaces and Boilers

Description of Measure

This section covers high efficiency gas fired furnaces and boilers in commercial applications. Furnace measures include standalone furnaces, high efficiency furnace sections in rooftop AC systems and furnaces included in split AC systems.

Method for Calculating Energy Savings

$$\Delta\text{therms} = \text{units} \times \frac{\text{kBtuh}_{\text{in}}}{\text{unit}} \times \left(\frac{\overline{\eta}_{ee}}{\overline{\eta}_{base}} - 1 \right) \times \frac{EFLH_{heat}}{100}$$

where:

Δtherms	= gross annual gas savings
units	= number of units installed
kBtuh/unit	= the nominal heating input capacity in kBtu/hr
η	= seasonal average efficiency (0-100)
$\text{EFLH}_{\text{heat}}$	= heating equivalent full-load hours (relative to nameplate)

The nominal ***heating input capacity*** is the nameplate input rating of the unit in kBtu/hr.

The ***seasonal average efficiency*** of the furnace or boiler is the ratio of the heating output to the fuel input (in consistent units) over a heating season. This factor accounts for combustion efficiency, standby losses, cycling losses, and other sources of inefficiency within the furnace itself. The ***AFUE*** is an estimate of the seasonal heating energy efficiency of furnaces and small boilers (< 300 kBtu/hr) for an average US city calculated according to a standard US DOE method and reported by the furnace or boiler manufacturer. Programs should use the manufacturers' rated AFUE until data can be developed that are more appropriate for NY climates.

The ***thermal efficiency*** Et is an instantaneous full load efficiency, including jacket losses. Boilers 300 kBtu/hr and larger should use the rated thermal efficiency as a proxy for the seasonal average boiler efficiency. Combustion efficiency (Ec) may be used if Et is not available.

Heating equivalent load hours are defined as the ratio of the annual building heating energy to the nameplate capacity:

$$\text{EFLH}_{\text{heat}} = \frac{\text{Annual Heating Energy (Btu)}}{\text{Nameplate capacity (Btu/hr)}}$$

Heating equivalent full load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency ($\overline{\eta}_{base}$) is defined by the 2010 Energy Conservation Construction Code of New York State (ECCNYS) as follows:

Equipment Type	Size Range	Minimum Efficiency
Furnace	< 225 kBtu/hr	78% AFUE
		80% Et
Hot Water Boilers	< 300 kBtu/hr	80% AFUE
	>= 300 – 2500 kBtu/hr	75% Et and 80%Ec
	> 2500 kBtu/hr	80% Ec
Steam Boilers	< 300 kBtu/hr	75% AFUE
	>= 300 – 2500 kBtu/hr	75% Et and 80% Ec
	> 2500 kBtu/hr	80% Et

Compliance Efficiency from which Incentives are Calculated

Efficient furnace or boiler efficiency ($\overline{\eta}_{ee}$) is the manufacturer's nameplate efficiency for the installed equipment. The minimum efficiency for incentives is defined as follows:

Equipment Type	Size Range	Minimum Efficiency
Furnace	All	Tier 1: 92% AFUE Tier 2: 95% AFUE
Non-Condensing Hot Water Boilers	< 300 kBtu/hr	85% AFUE
	>= 300 – 2500 kBtu/hr	85% Et or 88% Ec
	> 2500 kBtu/hr	88% Ec
Condensing Hot Water Boilers	< 300 kBtu/hr	90% AFUE
	>= 300 – 2500 kBtu/hr	90% Et or 93% Ec
	> 2500 kBtu/hr	93% Ec
Steam Boilers	< 300 kBtu/hr	82% AFUE

Operating Hours

Operating hour assumptions for the prototypical building models are described in Appendix A.

Non-Gas Benefits - Annual Electric Savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
$kBtuh_{in}$/unit		From application.
$n_{base,}$	See table above	Baseline established by ECCCNYS by equipment type and size
n_{ee}		From application; use units consistent with baseline efficiency.
$EFLH_{heat}$		Lookup based on building type and location
Building type		From application

Notes & References

1. ECCCNYS 2010 based on ASHRAE 90.1-2007

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The ***unit energy and demand savings*** across several commercial building types are shown in Appendix K. If building type does not match one of the types shown in Appendix K, use building type = other.

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Method for Calculating Energy Savings

$$\Delta\text{therm} = units \times \left[\frac{GPD \times 365 \times 8.3 \times \overline{\Delta T_w}}{100{,}000} \times \left[\frac{1}{E_{c,base}} - \frac{1}{E_{c,ee}} \right] + \left(\frac{UA_{base}}{E_{c,base}} - \frac{UA_{ee}}{E_{c,ee}} \right) \times \frac{\Delta T_s}{100{,}000} \times 8760 \right]$$

where:

Δtherm = gross annual gas savings
units = number of indirect water heaters installed under the program
UA_{base} = overall heat loss coefficient of base tank type water heater (Btu/hr-°F)
UA_{ee} = overall heat loss coefficient of indirect water heater storage tank (Btu/hr-°F)
ΔT_s = temperature difference between the stored hot water and the surrounding air (°F)
GPD = average daily water consumption (gallons/day)
$\overline{\Delta T}_w$ = average difference between the cold inlet temperature and the hot water delivery temperature (°F)
$E_{t,ee}$ = energy efficient indirect water heater boiler thermal efficiency
$E_{t,base}$ = baseline water heater efficiency (=RE_{base} if tank type baseline; $E_{t,base}$ if indirect baseline)
8.3 = conversion factor (Btu/gallon-°F)
100,000 = conversion factor (Btu/therm)
365 = conversion factor (days/yr)

Proposed Deemed Values for Gallons of Hot Water Use per Day (GPD) by Building Type

Building Type	GPD	Rate	Notes	Source
Assembly	150	5 per seat	water not HOT water; assume 10% hot water, 300 seats	http://www.p2pays.org/ref/42/41980.pdf
Big Box	100		assume like Small Office	Staff Estimate
Fast Food	630	0.7 GPD per meal	50 meals per hour, 18 hours per day	NY TRM
Full Service Restaurant	1,152	2.4 GPD per meal	40 meals per hour, 12 hours per day	NY TRM
Grocery	200		assume 2x Big Box	Staff Estimate
Hospital	12,000	300 GPD per bed	water not HOT water; assume 50% hot water, 80 beds	http://www.p2pays.org/ref/42/41980.pdf
Large Office	500	1.0 GPD per person	assume 500 ppl	NY TRM
Light Industrial	1,250	25 GPD per person per shift	water not HOT water, assume half hot water, 100 people/day	http://www.p2pays.org/ref/42/41980.pdf
Multi-family high-rise	920	46 GPD per unit	20 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/09)	NY TRM
Multi-family low-rise	276	46 GPD per unit	6 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/09)	NY TRM
Primary School	300	0.6 GPD per student	500 students; reduce days per year to reflect school calendar	NY TRM
Small Office	100	1.0 GPD per person	100 people	NY TRM
Small Retail	50		Half of Big Box	Staff Estimate
Auto Repair	29		1-person household	Staff Estimate
Community College	1,440		assume like Secondary School	Staff Estimate
Dormitory	14,700		Single-person household - 500 students	Staff Estimate
Heavy Industrial	1,250	25 GPD per person per shift	water not HOT water; assume half hot water, 100 people/day	http://www.p2pays.org/ref/42/41980.pdf
Hotel	9,000		3/4 of Hotel	Staff Estimate
Industrial Refrigeration	29		Assume like Auto Repair	Staff Estimate
Motel	4,500		Assume half of Hotel - laundry done on site	Staff Estimate
Multi Story Retail	75		1.5* Small Retail	Staff Estimate
Religious	150		Assume like Assembly	Staff Estimate
Secondary School	1,440	1.8 GPD per student	800 students; reduce days per year to reflect school calendar	NY TRM
University	3,450	69 GPD per student	water not HOT water; assume 10% hot water, 500 students	http://www.p2pays.org/ref/42/41980.pdf
Warehouse	100		assume like Small Office	Staff Estimate

Water heater size (gal)	Height (in)	Diameter (in)	UA (Btu/hr-F)				
			Bare tank	Fiberglass		Foam	
				1 in	2in	1 in	2in
140	76	24	47.9	12.0	6.2	9.6	4.9
200	72	30	60.9	14.7	7.6	11.7	6.0
250	84	30	68.1	16.8	8.6	13.3	6.9
350	88	36	88.8	21.5	11.0	17.1	8.7
400	97	36	95.3	23.3	11.9	18.5	9.5
500	74	48	115.9	26.3	13.3	20.9	10.6
750	106	48	146.9	34.9	17.7	27.7	14.1
1000	138	48	177.9	43.5	22.1	34.6	17.6

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Pipe Insulation

This section covers pipe insulation in space heating and domestic hot water (DHW) system distribution system applications. The savings depend on the type and size of the pipe, insulation type and thickness, hot water temperature and piping system ambient temperature.

Method for Calculating Energy Savings

$$\Delta kW_S = L \times \frac{\left[(UA/L)_{base} - (UA/L)_{ee}\right]}{\eta_{heater} \times 3412} \times \Delta T_S \times CF_S$$

$$\Delta kWh = L \times \frac{\left[(UA/L)_{base} - (UA/L)_{ee}\right]}{\eta_{heater} \times 3412} \times \overline{\Delta T} \times hr$$

$$\Delta therm = L \times \frac{\left[(UA/L)_{base} - (UA/L)_{ee}\right]}{\eta_{heater} \times 100{,}000} \times \overline{\Delta T} \times hr$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
L	= length of insulation installed
ΔT	= temperature difference between water within the pipe and air under peak conditions
$\overline{\Delta T}$	= average temperature difference between water within the pipe and air temperature (°F)
UA/L	= overall pipe heat loss coefficient per unit length (Btu/hr-°F-ft)
CF	= coincidence factor
3412	= conversion factor (Btu/kWh)

8760 = conversion factor (hr/yr)
100,000 = conversion factor (Btu per therm)
η_{heater} = water heater or boiler efficiency

The ***overall heat transfer coefficient*** per foot of pipe for the base and improved (insulated) piping is shown in the tables below.

Baseline Uninsulated Pipe Heat Loss Coefficient (UA/L) in Btu/hr-°F-ft

Pipe Size (nominal) (in.)	Bare Copper Piping			Bare Steel Piping	
	Service Hot Water	Hot water heat	Steam heat	Hot water heat	Steam heat
0.75	0.40	0.45	0.49	0.73	0.78
1	0.50	0.56	0.61	0.89	0.95
1.25	0.59	0.67	0.72	1.10	1.18
1.5	0.68	0.78	0.83	1.24	1.33
2	0.86	0.98	1.05	1.52	1.63
2.5	1.04	1.18	1.26	1.81	1.94
3	1.21	1.37	1.47	2.16	2.32
4	1.54	1.75	1.88	2.72	2.92

Insulated Copper Pipe Heat Loss Coefficient (UA/L) in Btu/hr-°F-ft

Pipe Size (nominal) (in.)	Fiberglass				Rigid foam			
	0.5 in	1.0 in	1.5 in	2.0 in	0.5 in	1.0 in	1.5 in	2.0 in
0.75	0.17	0.11	0.09	0.08	0.12	0.08	0.06	0.05
1	0.21	0.13	0.10	0.09	0.15	0.09	0.07	0.06
1.25	0.24	0.15	0.11	0.10	0.17	0.10	0.08	0.07
1.5	0.27	0.16	0.13	0.11	0.20	0.12	0.09	0.08
2	0.34	0.20	0.15	0.12	0.24	0.14	0.11	0.09
2.5	0.41	0.23	0.17	0.14	0.29	0.17	0.12	0.10
3	0.47	0.26	0.19	0.16	0.34	0.19	0.14	0.11
4	0.60	0.33	0.24	0.19	0.43	0.24	0.17	0.14

Insulated Steel Pipe Heat Loss Coefficient (UA/L) in Btu/hr-°F-ft

Pipe Size (nominal) (in.)	Fiberglass				Rigid foam			
	0.5 in	1.0 in	1.5 in	2.0 in	0.5 in	1.0 in	1.5 in	2.0 in
0.75	0.20	0.12	0.10	0.08	0.14	0.09	0.07	0.06
1	0.23	0.14	0.11	0.09	0.17	0.10	0.08	0.07
1.25	0.28	0.17	0.13	0.11	0.20	0.12	0.09	0.08
1.5	0.31	0.18	0.14	0.12	0.22	0.13	0.10	0.08
2	0.37	0.21	0.16	0.13	0.27	0.15	0.12	0.10
2.5	0.44	0.25	0.18	0.15	0.32	0.18	0.13	0.11
3	0.52	0.29	0.21	0.17	0.38	0.21	0.15	0.12
4	0.65	0.36	0.26	0.21	0.47	0.26	0.18	0.15

The ***efficiency*** of an electric storage type water heater is assumed to be 0.97. The efficiency of a non-condensing storage type water heater is assumed to be 0.75. For space heating applications, the efficiency of a gas hot water boiler is assumed to be 0.80 and the efficiency of a gas steam heating boiler is assumed to be 0.75.

The ***ambient temperature difference*** between the water temperature and the ambient room temperature is used to calculate the pipe losses. Water heaters are generally located in conditioned or partially conditioned spaces to avoid freezing. A room temperature of 70°F is the default value. A water heater set point temperature of 130°F is the default value. Similarly, space heating boilers are generally located in conditioned or partially conditioned spaces to avoid freezing. A room temperature of 60°F is the default value. An average water temperature of 160°F is the default value for hot water boilers, and an average steam pipe temperature of 190°F is the default value for steam boilers.

The ***coincidence factor*** is defined as the average fraction of the peak savings for the measure that occurs at the time of system peak. Since the measure affects standby losses, water heater savings occur year-round. Boiler systems are assumed to be turned off in the summer, so there are no savings in the summer.

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor (water heater)	1.0
Coincidence factor (space heating boiler)	0.0

Baseline Efficiencies from which Savings are Calculated

The UA_{base} assumes uninsulated copper pipe for water heating applications, and uninsulated copper or steel pipes for space heating applications.

Compliance Efficiency from which Incentives are Calculated

The UA_{ee} for insulated pipes was calculated for fiberglass and rigid foam pipe insulation of various thicknesses.

Service hot water pipe insulation for non-recirculating systems common in single family buildings is limited to the first 12 feet of hot water supply pipe leaving the water heater. Recirculating systems common in multifamily buildings should use the full length of installed pipe insulation to calculate savings.

Space heating pipe insulation is limited to insulation installed in unheated spaces only.

Operating Hours

The water heater is assumed to be available during all hours.

Single family and multifamily low rise buildings should use the heating equivalent full-load hours as shown in Appendix G. Systems in high rise multifamily buildings should use 3240 operating hours per year.

Summary of Variables and Data Sources

Variable	Value	Notes
L	From application	
ΔT	60°F (service hot water) 100°F (hot water heat) 130°F (steam heat)	130°F hot water temp, 70°F room temp 160 °F hot water temp, 60°F room temp 190 °F steam temp, 60°F room temp
$\overline{\Delta T}$	60°F (service hot water) 100°F (hot water heat) 130°F (steam heat)	130°F hot water temp, 70°F room temp 160 °F hot water temp, 60°F room temp 190 °F steam temp, 60°F room temp
UA/L	From table above	Pick value based on pipe size, insulation type and insulation thickness
CF	1.0	
η_{heater}	0.97 (elec water heater) 0.75 (gas water heater) 0.80 (gas hot water heat) 0.75 (gas steam heat)	
hr	Service hot water: 8760hr Space Heat: $EFLH_{heat}$ (SF and MF lowrise) 3240 (MF high-rise)	$EFLH_{heat}$ from Appendix G.

Notes & References

1. The uninsulated pipe losses were obtained from the 2001 ASHRAE Handbook of Fundamentals, Chapter 25, Tables 11A and 12.
2. Insulated pipe losses were calculated using a k value of 0.25 Btu-in/SF-°F for fiberglass and 0.18 Btu-in/SF-°F for rigid foam insulation. Pipe wall resistance and exterior film resistance were neglected.

Evaluator Fan Controls

Description of Measure

Walk-in cooler and freezer evaporator fans often run continually, requiring more air to be blown across the evaporator than needed to cool the evaporator. This measure consists of a control system that turns the fan on only when the unit's thermostat is calling for the compressor to operate, shutting the fan off shortly after the desired temperature is reached and the compressor is turned off.

Savings Estimation Approach

The savings from this measure is highly dependent on the type, size and condition of the coolers and freezers fitted with fan controls. As a result an estimate of the typical unit must be based on the program's projection of what types and sizes of units will be served and the condition of those units to function.

In general the following estimate approach must be made for the typical units that the program is expected to control:

ΔkWh = ΔkWh EF + ΔkWh RH + ΔkWh EC

where:
ΔkWh EF = Savings due to Evaporator Fan being off
ΔkWh RH = Savings due to reduced heat from Evaporator Fans
ΔkWh EC = Savings due to the electronic controls on compressor and evaporator

ΔkWh EF = $kW_{fan} * FLH_{fan} * F_{off}$

where:
kW_{fan} = Fan kW
$=(V * A * (phase)^{0.5} * PF_{fan})/1000$
V_{fan} = nameplate fan volts
A_{fan} = nameplate fan amps
$Phase_{fan}$ = number of phases (1 or 3)
PF_{fan} = power factor for fan motor
FLH_{fan} = Annual operating hours
F_{off} = Fraction of time that Evaporator Fan is turned off.

$\Delta kWh\ RH = \Delta kWh\ EF * 0.28 * kW/ton$

where:

$\Delta kWh\ EF$ = Savings due to Evaporator Fan being off.

0.28 = unit conversion (ton/kW)

kW/ton = compressor efficiency (kW/ton)

$$\Delta kWh\ EC = (kW_{comp} * ((FLH_W) + (FLH_s)) * F_{control}) + (kW_{fan} * FLH_{fan} * (1-F_{off}) * F_{control})$$

where:

kW_{comp} = Compressor kW

$= (V_{comp} * A_{comp} * (phase_{comp})^{0.5} * PF_{comp})/1000$

V_{comp} = Compressor nameplate volts

A_{comp} = Compressor nameplate amps

Phase = number of phases (1 or 3)

PF_{comp} = power factor for compressor

FLH_s = Compressor summer FLH

$= Cycle_{summer} * hr_{summer}$

FLH_w = Compressor winter FLH

$= Cycle_{winter} * hr_{winter}$

F_{off} = Fraction of time that Evaporator Fan is turned off.

$F_{control}$ = Fraction of time compressor and fans are off due to electronic controls

A_{comp} = Nameplate Amps of Compressor

V_{comp} = Nameplate Volts of Compressor

$Phase_{comp}$ = Phase of Compressor (1 or 3)

$\Delta kW = kW_{fan} * DF$

<u>Summary of Variables and Data Sources</u>

Variable	Value	Notes
PF_{fan}	0.55	National Resource Management (NRM) - Program Implementer
PF_{comp}	0.85	National Resource Management (NRM) - Program Implementer
Op hr	8760	Hours per year
F_{off}	0.352	Estimate by NRM based on downloads of hours of use data from the electronic controller.
$F_{control}$	0.05	National Resource Management (NRM) - Program Implementer
kW/ton	1.6	Typical refrigeration system efficiency
$Cycle_{summer}$	0.55	Average summer duty cycle
Hr_{summer}	6565	Summer season hours/yr
$Cycle_{winter}$	0.35	Average winter duty cycle
Hr_{winter}	2195	Winter season hours/yr
DF	0.228	Based on New England Power Service Co. report “Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls”, HEC, June 28, 1996

Electronically Commutated Motors (ECM) for Refrigerated Cases and Walk-In Cooler Fans

EC Motor retrofits in Walk-in Coolers and Freezers

kWh Savings = kWh $Savings_{EF}$ + kWh $Savings_{RH}$

Where:

kWh $Savings_{EF}$ = Savings due to Evaporator Fan Motors being replaced
kWh $Savings_{RH}$ = Savings due to reduced heat from Evaporator Fans

Where each component is calculated in the following manner:

kWh $Savings_{EF}$ = ($Amps_{EF}$ * $Volts_{EF}$ * $\sqrt{Phase}_{EF}$ * 0.55 * (8,760 or 5,600) * 65%)/1000

Where:

$Amps_{EF}$	= Nameplate Amps of Evaporator Fan
$Volts_{EF}$	= Nameplate Volts of Evaporator Fan
$Phase_{EF}$	= Phase of Evaporator Fan
0.55	= Power Factor/Adjustment, estimate by National Resource Management, NRM based on their experience over the past 15 years.
8,760	= Annual operating hours if CoolTrol is not part of installation
5,600	= Annual operating hours if CoolTrol is part of installation
65%	= Percent reduction of load by replacing motors. This value is an estimate by NRM based on several pre and post meter readings of installations. This is supported by RLW report for National Grid, “Small Business Services, Custom Measure Impact Evaluation”, March 23, 2007.

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Appendix A: Prototypical Building Descriptions
Refrigerated Warehouse

A prototypical building energy simulation model for a refrigerated warehouse building was developed using the DOE-2.2R[22] 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

Model Parameter	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
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

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Appendix A: Prototypical Building Descriptions
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.

[22] DOE-2.2R is a specialized version of the DOE-2.2 program, designed specifically to model refrigeration systems.

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 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 deg 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 deg F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

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Appendix A: Prototypical Building Descriptions
Commercial Building Prototypes

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.

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Appendix A: 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)[23] study, with adjustments made for local building practices and climate.

Three separate models were created to represent general vintages of buildings:

1. 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.
2. 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.
3. New construction conforming to the 2007 Energy Conservation Code of New York State for residential buildings. This vintage is referred to as the "new" vintage, and covers buildings constructed from 2007 to present.

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Weighting Factors for Commercial Building Calculations

The Tech Manual 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:

[23] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Building Type	AC with gas heat	Heat Pump	AC with elec heat	Electric heat only	Gas heat only
Assembly	0.67	0.08	0.12	0.03	0.14
Auto Repair	0.61	0.08	0.10	0.04	0.24
Big Box	0.64	0.07	0.18	0.02	0.07
Elementary School	0.68	0.11	0.11	0.01	0.08
Fast Food	0.64	0.09	0.18	0.01	0.06
Full Service	0.64	0.09	0.18	0.01	0.06
Grocery	0.64	0.07	0.18	0.02	0.07
Light Industrial	0.46	0.06	0.15	0.10	0.37
Motel	0.53	0.15	0.17	0.02	0.07
Religious	0.59	0.11	0.13	0.03	0.15
Small Office	0.63	0.10	0.19	0.00	0.02
Small Retail	0.64	0.07	0.18	0.02	0.07
Warehouse	0.46	0.06	0.15	0.10	0.37
Other	0.60	0.09	0.16	0.03	0.14

Appendix C: Standard Fixture Watts

Shown below is first page only of Appendix C, See DPS website for entire Appendix C.

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
		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
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

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Building: Single Family **City: NYC** **HVAC: Gas Heat, no AC** **Measure: Roof Insulation**

R_{eff} Base	**0**			**11**			**19**			**30**			**38**		
R_{eff} 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	0.0	224.4												
19	118.4	0.0	252.6	12.8	0.0	28.2									
30	125.9	0.0	268.8	20.3	0.0	44.4	7.5	0.0	16.2						
38	128.8	0.0	275.1	23.2	0.0	50.7	10.4	0.0	22.5	2.9	0.0	6.3			
49	131.4	0.0	280.7	25.8	0.0	56.3	13.0	0.0	28.2	5.5	0.0	11.9	2.6	0.0	5.6
60	133.1	0.0	284.3	27.5	0.0	59.9	14.7	0.0	31.7	7.2	0.0	15.5	4.3	0.0	9.2

Record of Revision Number 7-13-25

Appendix E. Opaque Shell Measure Savings
Single Family Residential Insulation Upgrades

Note: R-values in Tables are effective R-values (R_{eff}) including adjustments for compression and installation quality.

Building: Single Family **City: Binghamton** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

R_{eff} Base	0			11			13			17			19		
R_{eff} 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	46.2	0.043	54.0												
13	54.3	0.054	62.6	8.1	0.011	8.7									
17	64.3	0.065	74.8	18.1	0.022	20.8	10.0	0.011	12.1						
19	67.4	0.065	79.2	21.2	0.022	25.3	13.1	0.011	16.6	3.1	0.000	4.4			
21	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
25	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
27	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

Building: Single Family **City: Binghamton** **HVAC: Heat Pump** **Measure: Wall Insulation**

R_{eff} Base	0		11		13		17		19	
R_{eff} Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	846.0	0.054								
13	978.9	0.054	132.9	0.000						
17	1165.7	0.065	319.7	0.011	186.9	0.011				
19	1232.2	0.076	386.2	0.022	253.3	0.022	66.4	0.011		
21	1288.1	0.076	442.1	0.022	309.2	0.022	122.4	0.011	55.9	0.000
25	1374.2	0.087	528.2	0.033	395.3	0.033	208.4	0.022	142.0	0.011
27	1407.8	0.087	561.8	0.033	242.0	0.033	242.0	0.022	175.6	0.011

Building: Single Family **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

R_{eff} Base	**0**		**11**		**13**		**17**		**19**	
R_{eff} Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1241.4	0.043								
13	1440.0	0.054	198.6	0.011						
17	1717.9	0.065	476.5	0.022	277.9	0.011				
19	1818.7	0.065	577.3	0.022	378.7	0.011	100.8	0.000		
21	1903.9	0.076	662.5	0.033	463.9	0.022	186.0	0.011	85.2	0.011
25	2035.0	0.076	793.6	0.033	595.1	0.022	317.1	0.011	216.3	0.011
27	2087.1	0.076	845.8	0.033	647.2	0.022	369.3	0.011	268.5	0.011

Building: Single Family **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

R_{eff} Base	**0**		**11**		**13**		**17**		**19**	
R_{eff} Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1222.6	0.000								
13	1417.4	0.000	194.8	0.000						
17	1691.4	0.000	468.8	0.000	274.0	0.000				
19	1791.5	0.000	568.8	0.000	374.1	0.000	100.0	0.000		
21	1874.9	0.000	652.3	0.000	457.5	0.000	183.5	0.000	83.5	0.000
25	2004.4	0.000	781.8	0.000	587.0	0.000	313.0	0.000	213.0	0.000
27	2055.6	0.000	833.0	0.000	638.2	0.000	364.2	0.000	264.1	0.000

Building: Single Family **City: Binghamton** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

R_{eff} Base	0			11			13			17			19		
R_{eff} 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	27.3	0.000	54.0												
13	31.8	0.000	62.6	4.4	0.000	8.7									
17	37.8	0.000	74.8	10.5	0.000	20.8	6.1	0.000	12.1						
19	40.1	0.000	79.2	12.8	0.000	25.3	8.3	0.000	16.6	2.3	0.000	4.4			
21	41.9	0.000	82.9	14.6	0.000	28.9	10.2	0.000	20.3	4.1	0.000	8.1	1.8	0.000	3.7
25	44.9	0.000	88.7	17.6	0.000	34.7	13.1	0.000	26.0	7.0	0.000	13.9	4.8	0.000	9.4
27	46.0	0.000	90.9	18.6	0.000	37.0	14.2	0.000	28.3	8.1	0.000	16.2	5.9	0.000	11.7

Building: Single Family **City: Binghamton** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

R_{eff} Base	0			11			19			30			38		
R_{eff} 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	311.4	0.290	332.9												
19	350.9	0.341	374.4	39.4	0.051	41.5									
30	369.8	0.358	398.8	58.4	0.068	65.9	18.9	0.017	24.4						
38	377.1	0.375	408.2	65.7	0.085	75.3	26.3	0.034	33.8	7.3	0.017	9.4			
49	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
60	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

Building: Single Family City: Binghamton HVAC: Heat Pump Measure: Roof Insulation

R_{eff} Base	0		11		19		30		38	
R_{eff} Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5853.1	0.273								
19	6534.8	0.324	681.7	0.051						
30	6923.9	0.358	1070.8	0.085	389.1	0.034				
38	7075.4	0.358	1222.4	0.085	540.6	0.034	151.5	0.000		
49	7208.7	0.375	1355.6	0.102	673.9	0.051	284.8	0.017	133.3	0.017
60	7294.7	0.375	1441.6	0.102	759.9	0.051	370.8	0.017	219.3	0.017

Building: Single Family City: Binghamton HVAC: AC with Electric Heat Measure: Roof Insulation

R_{eff} Base	0		11		19		30		38	
R_{eff} Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7921.3	0.290								
19	8887.9	0.341	966.6	0.051						
30	9449.0	0.358	1527.6	0.068	561.1	0.017				
38	9668.3	0.375	1746.9	0.085	780.4	0.034	219.3	0.017		
49	9861.9	0.392	1940.6	0.102	974.1	0.051	413.0	0.034	193.7	0.017
60	9987.0	0.392	2065.7	0.102	1099.1	0.051	538.1	0.034	318.8	0.017

Building: Single Family City: Binghamton HVAC: Electric Heat, no AC Measure: Roof Insulation

R_{eff} Base	0		11		19		30		38	
R_{eff} Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7775.8	0.000								
19	8723.0	0.000	947.3	0.000						
30	9277.1	0.000	1501.4	0.000	554.1	0.000				
38	9493.9	0.000	1718.1	0.000	770.8	0.000	216.7	0.000		
49	9683.4	0.000	1907.7	0.000	960.4	0.000	406.3	0.000	189.6	0.000
60	9807.0	0.000	2031.2	0.000	1084.0	0.000	529.9	0.000	313.1	0.000

Building: Single Family **City: Binghamton** **HVAC: Gas Heat, No AC** **Measure: Roof Insulation**

R_{eff} Base	**0**			**11**			**19**			**30**			**38**		
R_{eff} 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	166.0	0.000	333.1												
19	186.3	0.000	374.6	20.3	0.000	41.5									
30	198.1	0.000	398.8	32.1	0.000	65.7	11.8	0.000	24.2						
38	202.7	0.000	408.4	36.7	0.000	75.3	16.4	0.000	33.8	4.6	0.000	9.6			
49	206.8	0.000	416.7	40.8	0.000	83.6	20.5	0.000	42.2	8.7	0.000	17.9	4.1	0.000	8.4
60	209.4	0.000	422.2	43.3	0.000	89.1	23.0	0.000	47.6	11.3	0.000	23.4	6.7	0.000	13.8

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Appendix H: Residential Distribution System Efficiency in Cooling Mode (Attic Ducts)

Engine Block Heater Timers

Description of Measure

This section covers timers used to control engine block heaters on farm equipment engines such as tractors, skid steers, truck, generators, and so on. The timers are used to control existing engine block heaters.

Method for Calculating Summer Peak Demand and Energy Savings

$\Delta kW_s = 0$

$$\Delta kWh = \text{units} \times \frac{\text{Watts}_{\text{heater}}}{1000} \times (\text{hr/day}_{\text{base}} - \text{hr/day}_{\text{timer}}) \times \text{day/year}$$

where:

ΔkW_s	= gross summer coincident demand savings
ΔkWh	= gross annual energy savings
units	= number of timers installed under the program
$Watts_{heater}$	= wattage of engine block heater
hr/day_{base}	= avg hours per day heater plugged in
hr/day_{timer}	= avg hours per day timer turns the heater on
day/yr	= number of days per year heater is used

$Watts_{heater}$ is defined as the wattage of the engine block heater under control. This value is recorded by the customer on the application.

hr/day_{base} is defined as the average number of hours the engine block heater is plugged in and active before the installation of the timer. This value is recorded by the customer on the application.

hr/day_{timer} is defined as the number of hours the engine block heater is controlled on by the timer. The on time and off time are set by the user. The number of hours required to sufficiently warm the engine depends on the size (mass) of the engine, the heating capacity of the heater and the environmental temperature. Estimates of 1 to 4 hours of block heater operation are common in the literature. A deemed value of 2.0 hours per day shall be used (1).

day/yr is defined as the number of days in the year the heater is used. This value is calculated from the customer reported heater use start and end date on the application.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be the existing engine block heater plugged in and operational during the hours reported by the customer.

Compliance Efficiency from which Incentives are Calculated

The measure is defined as the existing block heater controlled by the timer. Timer on hours are set by the customer. A deemed value of 2.0 hours per day shall be used.

Non-Electric Benefits - Annual Fossil Fuel Savings

None expected.

Summary of Variables and Data Sources

Variable	Value	Notes
Units		From application.
$Watts_{heater}$		From application
hr/day_{base}		From application
hr/day_{timer}	2.0	Deemed value for timer operation
day/yr		From application

Notes & References

1. Deemed value for timer operation taken from Wisconsin Public Service calculator for tractor heater timers. See http://www.wisconsinpublicservice.com/business/farm_tractor.aspx

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Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		Calc from baseline water heater EF or standby loss.
UA_{ee}		Calc from lookup table based on tank volume and insulation thickness. Use 1 inch if insulation thickness not known.
delta T_s	T_{set} - T_{amb}	
GPD		Default to 78 for SF. Use GPD based on number of units for MF; otherwise from application
delta T_w	T_{set} - T_{main}	
Et_{base}	0.75 (gas)	
Et_{ee}		From application
V		From application
T_{set}	130	
T_{amb}	65	
T_{mains}		Avg T_{mains} based on upstate or downstate
Capacity (Q)	40,000	See table for storage type gas water heaters above
EF_{base}		Calc from tank volume
RE_{base}		0.75
V_{base}		Same as V
SL_{base}	380 Btu/hr	Based on 120 gal tank with 2 in foam insulation

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Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application or use 5 ton as default. Use 0 if no central cooling
$SEER_{base}$	10	
$EFLH_{cool}$		Vintage weighted average by city.
ESF_{cool}	0.09	
If heat pump:		
$kBtuh/unit_{out}$		From application.
$HSPF_{base}$	6.8	
If furnace:		
$kBtuh_{in}/unit$		From application.
If boiler:		
$kBtuh_{in}/unit$		From application.
$EFLH_{heat}$		Vintage weighted average by city.
ESF_{heat}	0.068	

Evaporator Fan Controls

Description of Measure

Walk-in cooler and freezer evaporator fans often run continually, requiring more air to be blown across the evaporator than needed to cool the evaporator. This measure consists of a control system that turns the fan on only when the unit's thermostat is calling for the compressor to operate, shutting the fan off shortly after the desired temperature is reached and the compressor is turned off.

Savings Estimation Approach

The savings from this measure is highly dependent on the type, size and condition of the coolers and freezers fitted with fan controls. As a result an estimate of the typical unit must be based on the program's projection of what types and sizes of units will be served and the condition of those units to function.

In general the following estimate approach must be made for the typical units that the program is expected to control:

ΔkWh = ΔkWh EF + ΔkWh RH + ΔkWh EC

where:

ΔkWh EF = Savings due to Evaporator Fan being off
ΔkWh RH = Savings due to reduced heat from Evaporator Fans
ΔkWh EC = Savings due to the electronic controls on compressor and evaporator

ΔkWh EF = $kW_{fan} * FLH_{fan} * F_{off}$

where:

kW_{fan} = Fan kW
$=(V * A * (phase)^{0.5} * PF_{fan})/1000$
V_{fan} = nameplate fan volts
A_{fan} = nameplate fan amps
$Phase_{fan}$ = number of phases (1 or 3)
PF_{fan} = power factor for fan motor
FLH_{fan} = Annual operating hours
F_{off} = Fraction of time that Evaporator Fan is turned off.

$\Delta kWh\ RH = \Delta kWh\ EF * 0.28 * kW/ton$

where:

ΔkWh EF	= Savings due to Evaporator Fan being off.
0.28	= unit conversion (ton/kW)
kW/ton	= compressor efficiency (kW/ton)

$\Delta kWh\ EC = (kW_{comp} * ((FLH_W) + (FLH_s)) * F_{control}) + (kW_{fan} * FLH_{fan} * (1-F_{off}) * F_{control})$

where:

kW_{comp}	= Compressor kW
	$=(V_{comp} * A_{comp} * (phase_{comp})^{0.5} * PF_{comp})/1000$
V_{comp}	= Compressor nameplate volts
A_{comp}	= Compressor nameplate amps
Phase	= number of phases (1 or 3)
PF_{comp}	= power factor for compressor
FLH_s	= Compressor summer FLH
	$= Cycle_{summer} * hr_{summer}$
FLH_w	= Compressor winter FLH
	$= Cycle_{winter} * hr_{winter}$
F_{off}	= Fraction of time that Evaporator Fan is turned off.
$F_{control}$	= Fraction of time compressor and fans are off due to electronic controls
A_{comp}	= Nameplate Amps of Compressor
V_{comp}	= Nameplate Volts of Compressor
$Phase_{comp}$	= Phase of Compressor (1 or 3)

$\Delta kW = kW_{fan} * DF$

--

Electronically Commutated Motors (ECM) for Refrigerated Cases and Walk-In Cooler Fans

EC Motor retrofits in Walk-in Coolers and Freezers

kWh Savings = kWh $Savings_{EF}$ + kWh $Savings_{RH}$

Where:

kWh $Savings_{EF}$ = Savings due to Evaporator Fan Motors being replaced
kWh $Savings_{RH}$ = Savings due to reduced heat from Evaporator Fans

Where each component is calculated in the following manner:

kWh $Savings_{EF}$ = ($Amps_{EF}$ * $Volts_{EF}$ * $\sqrt{Phase}_{EF}$ * 0.55 * (8,760 or 5,600) * 65%)/1000

Where:

$Amps_{EF}$	= Nameplate Amps of Evaporator Fan
$Volts_{EF}$	= Nameplate Volts of Evaporator Fan
$Phase_{EF}$	= Phase of Evaporator Fan
0.55	= Power Factor/Adjustment, estimate by National Resource Management, NRM based on their experience over the past 15 years.
8,760	= Annual operating hours if Cooltrol is not part of installation
5,600	= Annual operating hours if Cooltrol is part of installation
65%	= Percent reduction of load by replacing motors. This value is an estimate by NRM based on several pre and post meter readings of installations. This is supported by RLW report for National Grid, "Small Business Services, Custom Measure Impact Evaluation", March 23, 2007.

And:

kWh $Savings_{RH}$ - (Savings due to reduced heat from fan motors) = kWh $Savings_{EF}$ * 0.28 * 1.6

Where:

kWh $Savings_{EF}$	= Savings due to Evaporator Fans being replaced (see above)
0.28	= unit conversion between kW and tons, See LED lighting Calculation for derivation
1.6	= Efficiency of typical refrigeration system, units are kW/ton

Refrigerated Case Motor Replacement

kWh Savings = (Annual motor kW A * 53% or 29% * 8,500) + Refrigeration savings due to reduced heat load from new motors.

Where:

kW A = metered load of case motors
53% = energy reduction if a shaded pole motors is being replaced. Based on numerous pre and post meterings conducted by NRM
29% = energy reduction if a PSC motor is being replaced. Based on numerous pre and post meterings conducted by NRM
8,500 = average runtime of case motors

Refrigeration Savings - (Savings due to reduced heat from fan motors) =

kWh Savings_{CM} * 0.28 * 1.6

Where:

kWh SavingsCM = Savings due to Case Motors being replaced (see above).
0.28 = unit conversion between kW and tons, see LED Lighting Calculation for derivation of value
1.6 = Efficiency of typical refrigeration system, units are kW/ton

Record of Revision Number 7-13-32

Boilers

Description of Measure

High efficiency condensing and non-condensing gas-fired hot water and steam boilers in single family and multi-family buildings.

Method for Calculating Energy Savings

$$\Delta \text{therms} = \text{units} \times \frac{\text{kBtuh}_{\text{in}}}{\text{unit}} \times \left(\frac{\overline{\eta}_{ee}}{\overline{\eta}_{base}} - 1 \right) \times \frac{EFLH_{heat}}{100}$$

High Efficiency Gas Furnaces

<u>Description of Measure</u>

This section covers high efficiency condensing gas furnaces with an AFUE > 92% in single family and multi-family applications.

<u>Method for Calculating Energy Savings</u>

$$\Delta\text{therms} = \text{units} \times \frac{\text{kBtuh}_{\text{in}}}{\text{unit}} \times \left(\frac{AFUE_{ee}}{AFUE_{base}} - 1 \right) \times \frac{EFLH_{heat}}{100}$$

Record of Revision Number 7-13-33

Indirect Water Heaters

Indirect water heaters are tank-type water heaters that are indirectly heated by hot water from a boiler rather than direct input from electric elements or gas burners. A heat exchanger separates the potable water in the water heater from the boiler water. The baseline assumption for indirect water heaters is a standard efficiency tank type water heater or an indirect system with a standard efficiency boiler.

<u>Method for Calculating Energy Savings</u>

$$\Delta\text{therm} = units \times \left[\frac{GPD \times 365 \times 8.3 \times \overline{\Delta T_w}}{100{,}000} \times \left[\frac{1}{E_{t,base}} - \frac{1}{E_{t,ee}} \right] + \left(\frac{UA_{base}}{E_{t,base}} - \frac{UA_{ee}}{E_{t,ee}} \right) \times \frac{\Delta T_s}{100{,}000} \times 8760 \right]$$

$$UA_{base} = \frac{\frac{1}{EF_{base}} - \frac{1}{RE_{base}}}{67.5 \times \left(0.000584 - \frac{1}{RE_{base} \times Cap_{base}} \right)}$$

$EF_{base} = 0.62 - 0.0019 V_{base}$

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Using the default values above, the tank UA for typical gas water heaters are shown in the Table below:

Water Heater Size	Gas Water Heater Tank UA
40	13.6
80	21.6
120	32.8

Tank overall heat loss coefficient ***(UA)*** for larger multi-family water heaters is calculated from the standby loss specification.

Larger tank UA values are shown below.

Water heater size (gal)	Height (in)	Diameter (in)	UA (Btu/hr-F)				
			Bare tank	Fiberglass		Foam	
				1 in	2in	1 in	2in
140	76	24	47.9	12.0	6.2	9.6	4.9
200	72	30	60.9	14.7	7.6	11.7	6.0
250	84	30	68.1	16.8	8.6	13.3	6.9
350	88	36	88.8	21.5	11.0	17.1	8.7
400	97	36	95.3	23.3	11.9	18.5	9.5
500	74	48	115.9	26.3	13.3	20.9	10.6
750	106	48	146.9	34.9	17.7	27.7	14.1
1000	138	48	177.9	43.5	22.1	34.6	17.6

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Standard assumptions for recovery efficiency and input capacity for small non-condensing water heaters[24] are:

Water Heater Type	Recovery efficiency	Capacity (Btu/hr)
Gas	0.75	40,000

[24] Values applicable to non-condensing water heaters with EF ≤ 0.68.

Water Heater

Description of Measure

Efficient instantaneous and storage type water heaters installed in whole-house applications.

Method for Calculating Energy Savings

$$\Delta kW_S = units \times \frac{(UA_{base} - UA_{ee}) \times \Delta T_s}{3412} \times DF_s \times CF_s$$

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T}}{3412} \times \left[\frac{1}{EF_{base}} - \frac{1}{\overline{\overline{COP}}} \right]$$

$$\Delta therm = units \times \frac{GPD \times 365 \times 8.3 \times \overline{\Delta T_w}}{100{,}000} \times \left[\frac{1}{EF_{base}} - \frac{1}{EF_{ee}} \right]$$

Water Heaters

Description of Measure

Efficient water heaters installed in whole-building applications.

Method for Calculating Energy Savings

$$\Delta kW_S = \text{units} \times \frac{(\text{UA}_{\text{base}} - \text{UA}_{\text{ee}}) \times \text{DT}_{\text{s}}}{3412} \times \text{DF}_{\text{s}} \times \text{CF}_{\text{s}}$$

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{3412} \times \left[\frac{1}{E_{t,base}} - \frac{1}{E_{t,ee}} \right]$$

$$\Delta therm = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{100{,}000} \times \left[\frac{1}{E_{t,base}} - \frac{1}{E_{t,ee}} \right]$$

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This relationship was used to adjust the New England data for New York locations, as shown below:

City	CDH(65)/24	Cooling EFLH
Albany	716	181
Binghamton	517	120
Buffalo	619	151
Massena	592	143
NYC	1374	382
Poughkeepsie	804	208
Syracuse	734	186

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Opaque Shell Insulation

Description of Measure

This section covers improvements to the thermal conductance of the opaque building shell, which includes upgrading insulation in walls, ceilings, floors, etc. Energy and demand saving are realized through reductions in the building heating and cooling loads.

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = SF \times (\Delta kW/SF) \times CF_S \times \frac{EER_{base}}{EER_{part}} \times \left[\frac{\eta_{dist,pk,base}}{\eta_{dist,pk,part}}\right]_{cool}$$

$$\Delta kWh = SF \times (\Delta kWh/SF) \times \frac{SEER_{base}}{SEER_{part}} \times \left[\frac{\overline{\eta}_{dist,base}}{\overline{\eta}_{dist,part}}\right]_{cool}$$

$$\Delta therm = SF \times (\Delta therm/SF) \times \frac{AFUE_{base}}{AFUE_{part}} \times \left[\frac{\overline{\eta}_{dist,base}}{\overline{\eta}_{dist,part}}\right]_{heat}$$

where:

EER_{base} = EER used in the simulations
EER_{part} = EER of cooling systems within participant population
$SEER_{base}$ = SEER used in the simulations
$SEER_{part}$ = SEER of cooling system within participant population
$AFUE_{base}$ = AFUE used in the simulations
$AFUE_{part}$ = AFUE of heating system within participant population

$\bar{\eta}_{dist,base}$	= distribution system seasonal efficiency used in simulations
$\bar{\eta}_{dist,part}$	= distribution system seasonal efficiency within participant population
$\eta_{dist,pk,base}$	= distribution system efficiency under peak conditions used in simulation
$\eta_{dist,pk,part}$	= distribution system efficiency under peak conditions within participant population
CF_s	= Peak coincidence factor (summer)

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<u>Method for Calculating Summer Peak Demand and Energy Savings</u>

$$\Delta kW_S = \text{units} \times \frac{\text{tons}}{\text{unit}} \times \left(kW/ton_{base} - kW/ton_{ee}\right) \times CF_S$$

$$\Delta kWh = \text{units} \times \frac{\text{tons}}{\text{unit}} \times \left(IPLV_{base} - IPLV_{ee}\right) \times EFLH_{cooling}$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
IPLV	= annual average chiller efficiency (kW/ton)
kW/ton	= full load chiller efficiency under peak conditions
$EFLH_{cooling}$	= cooling equivalent full-load hours
CF	= coincidence factor

The rated full load ***kW/ton*** at ARI rating conditions is used to define the efficiency under peak conditions. The ***IPLV*** as defined by ARI is used to define the annual average efficiency. These values represent average conditions across the US, and will be used until data specific to New York can be developed. 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 = 3.516 / COP
IPLV(kw/ton) = 3.516 / IPLV(COP)

Cooling equivalent full-load hours (EFLH) are defined as the ratio of the annual building cooling energy to the nameplate capacity:

$$EFLH_{cool} = \frac{\text{Annual kWh}_{cooling}}{kW_{peak,\ cooling}}$$

Cooling equivalent full load hours were calculated from a DOE-2.2 simulation of prototypical large office building. The prototype building characteristics are described in Appendix A. The CLH for built-up HVAC systems in commercial buildings in various NY locations are shown in Appendix G.

The ***coincidence factor*** is used to account for the fact that not all HVAC systems in all buildings in the population are operating at the same time. The coincidence factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of the system peak.

Recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for new construction varies by equipment type and size, and is shown in the table below.

Baseline Performance Assumptions

Equipment Category	Capacity Range	Baseline Efficiency (kw/ton)		Baseline Efficiency (COP)	
		Average	Peak	Average	Peak
Air Cooled Chiller	All	1.15	1.26	3.05	2.8
Water cooled Recip	All	0.70	0.84	5.05	4.2
Water cooled screw and scroll	< 150 tons	0.68	0.79	5.2	4.45
	150 – 300 tons	0.63	0.72	5.6	4.9
	> 300 tons	0.57	0.64	6.15	5.5
Water cooled centrifugal	< 150 tons	0.67	0.70	5.25	5.00
	150 – 300 tons	0.60	0.63	5.90	5.55
	> 300 tons	0.55	0.58	6.40	6.10

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See Record of Revision Number 7-13-30 above.

Refrigerators[25]

This section covers replacement of refrigerators with Energy Star models in single family and multi-family dwellings. High-efficiency refrigerators save energy and demand through improved compressor design, better case insulation, improved door seals, and improvements to defrost and anti-sweat heater controls. Both early replacement and normal replacements are covered in this section. The algorithms include an adjustment for the fraction of replaced refrigerators that enter the used appliance market. Programs that cannot demonstrate disabling or recycling of removed refrigerators should include this adjustment.[26]

Through early replacement, annual savings ranging from a low of 300 kWh per unit, to a high of about 700 kWh per unit are expected. Three options for estimating the annual consumption of a refrigerator being replaced early are provided.[27] The first is measuring/metering actual energy usage of the refrigerator(s) to be replaced in place. The second option is a nameplate approach, with adjustments for age and condition (where nameplate data are available). The third is use of conservative deemed, default estimates of baseline (existing) refrigerator consumption.

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City	Annual Average outdoor temperature (°/F)	T mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate Average	47.3	53.3
Long Island	56.5	62.5
NYC	56.5	55.0

[25] This section applies to refrigerators with and without freezers

[26] This chapter does not directly apply to retail rebate programs, especially with regard to this Market Effects Factor (below). This measure does not require a chapter, and its analysis can otherwise use materials in this chapter. Rebates at the retail level affect choice between new refrigerators, leaving no existing old one to be recycled or not.

[27] See Order Approving Modifications to the Technical Manual, Case 07-M-0548, July 18, 2011, pps. 18 – 20. In a unique provision to facilitate PA benefit cost analysis, the order provides a $75 default incremental cost for normal replacement of multifamily refrigerators, allowing use of a lesser value, not less than $35, if documented. Although refrigerators in single family homes tend to be larger than those in multifamily housing, $75 may still be used as the incremental cost for normal replacement.

Record of Revision Numbers 3-13-1

Appendix O: C&I Lighting Policy

See DPS Website

Record of Revision Numbers 5-11-1

Appendix M: Guidelines for Early Replacement Conditions

See DPS Website