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

Residential, Multi-Family, and Commercial/Industrial Measures

Version 2

December 10, 2014

New York State Department of Public Service
Office of Energy Efficiency and the Environment
3 Empire State Plaza
Albany, New York 12223

Version history of the New York State Technical Resource Manual:

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

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The New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multi-family, and Commercial/Industrial Measures, December 10, 2014, Version 2, was updated by the New York State Department of Public Service in consultation with the E^2 Working Group‟s Technical Resource Manual/Measure Classification Lists Subcommittee, representing all New York Program Administrators. Details on the Subcommittee may be found at,
www3.dps.ny.gov/W/PSCWeb.nsf/All/C0D82393BD42744085257CA90065E441?OpenDocument

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INTRODUCTION

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

HISTORY

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

Each measure now includes a section titled "Record of Revision." If the measure was not revised between its original publication (in 2008-2009) and its publication in the Consolidated Technical Resource Manual, the Revision Number is 0. If the measure was added/revised between its original publication (in 2008-2009) and its publication in the Consolidated Technical Manual, the Revision Number will correspond to the number of changes/additions of that measure (ex. 1 or 2). Since the publication of the Consolidated Technical Resource Manual, dated October 15, 2010, Staff has worked with the E^2 Working Group[2] and the Technical Resource Manual/Measure Classification Lists Subcommittee to review and approve proposed revisions utilizing the process established by Commission Order[3]. These revisions have been documented through the issuance of the Record of Revisions[4]. All revisions made subsequent to the release of the Consolidated Technical Resource Manual are listed using the DPS Staff-generated Revision Number, as stated in the approved Record of Revisions.

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

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

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

[4] A summary of all Records of Revisions[4] issued between October 15, 2010 and September 30, 2014 is provided at the end of this documentas an easy reference describing the content of the revisions. Actual Record of Revisions can be located at: www3.dps.ny.gov/W/PSCWeb.nsf/ArticlesByTitle/06F2FEE55575BD8A852576E4006F9AF7?OpenDocument (page down to Technical Manuals).

The release of this *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Program – Single and Multi-Family Residential & Commercial and Industrial Measures, Version 2*, incorporates all Records of Revision issued through September 30, 2014.

System Peak Demand Definition

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

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

Electricity

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

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

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

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

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

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

Natural Gas

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

NATURAL GAS PEAK SAVINGS DEFINITION

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

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

COINCIDENCE FACTOR

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

ANCILLARY NON-GAS FOSSIL FUEL IMPACTS

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

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

ANNUAL/LIFE-CYCLE SAVINGS

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

NET TO GROSS ADJUSTMENTS

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

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

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

Equivalent Full Load Hours (EFLH), for Heating or Cooling

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

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

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

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

APPLIANCE

CLOTHES WASHER

Measure Description

Residential clothes washers meeting the minimum qualifying efficiency standards established under the Energy Star Program. The washers are assumed to be located within the residential unit, not a commercial washer in a common area laundry room. There is natural gas energy savings associated with the thorough water removal from the clothes in the washer.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \Delta kWh_{washer} + \Delta kWh_{wh} + \Delta kWh_{dryer}$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times \Delta therm_{wh} + \Delta therm_{dryer}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$_{dryer}$	= Clothes dryer
$_{washer}$	= Clothes washer
$_{wh}$	= Water heater
CF	= Coincidence factor
8,760	= Hours in one year

Summary of Variables and Data Sources

Variable	Value	Notes
kWh		From table, based on water heater and dryer type
$_{wh}$	Water heater type	From application
$_{dryer}$	Clothes dryer type	From application
therm savings		Based on water heater and dryer type

Coincidence Factor (CF)

The recommended value for the coincidence factor is, based on data from the Efficiency Vermont TRM, CF = 0.06

Baseline Efficiencies from which Savings are Calculated

The table below shows the average savings in electricity and natural gas resulting from the installation of energy efficient clothes washers that meet Energy Star standards, in comparison to a minimum federal standard clothes washer. The electric savings are those associated with the clothes washer itself, reductions in hot water requirements from an electric water heater and reductions in electric dryer energy when the efficient washer removes more moisture from the clothes at the end of the cycle. The gas savings are the associated with reductions in hot water requirements from a gas-fired hot water heater and reductions in gas dryer energy when the efficient washer removes more moisture from the clothes at the end of the cycle. The gas and electric savings should be applied depending on the type of water heater and dryer associated with the efficient washer. The savings presented are taken directly from the EPA savings calculator. The number of wash cycles per year is assumed to be 392.

	Efficiency	Clothes Washer		Hot Water Heater		Dryer	
		Electric	Water	Natural Gas	Electric	Natural Gas	Electric
	MEF[7]	(kWh)	(Gallons)	(therm)	(kWh)	(therm)	(kWh)
Base Line	1.26	81	12,179	14.1	300	15.7	406
Energy Star	1.80	57	5,637	8.0	173	12.8	333
Savings		24	6,542	6.1	127	2.9	73

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL), single-family residential

Years: 11
Source: DEER

Effective Useful Life (EUL), multi-family residential

Years: 14
Source: NWPPC

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[7] MEF=Modified Energy Factor, The MEF measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity, the higher the number, the greater the efficiency.

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit energy savings data from the Energy Star website: See www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls
2. Technical Reference User Manual (TRM) No. 4-19, Efficiency Vermont, 9/5/2003 TRM

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010

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DEHUMIDIFIER

Measure Description

Residential stand-alone or whole-house dehumidifiers meeting the minimum qualifying efficiency standards established under the Energy Star® Program, Version 3.0[8]. Dehumidifiers have more efficient refrigeration coils, compressors, and fans than conventional models using lesser energy to remove moisture in residential buildings. Dehumidifiers originally qualified for the ENERGY STAR label in January 2001. Dehumidifiers that have earned this label are approximately 15% more efficient than non-qualified models.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$\Delta kWh =$ units × (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 reference 2). The *Energy Star® Dehumidifier Calculator* (Version 3.0) is used to create the energy savings tables.

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

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

Peak Coincident Demand Savings

$\Delta kW = units \times 0.0098 \times CF$

Annual Gas Energy Savings

$\Delta therms = N/A$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of units installed under the program
CF	= Coincidence factor
0.0098	= Unit peak demand reduction[9]

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh savings		Lookup based on capacity (pints per day)
Capacity (pints/day)		From application
ΔkW demand reduction	0.0098	

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0

Baseline Efficiencies from which Savings are Calculated

Energy Star® program requirements product specification for dehumidifiers Performance Criteria[10], Version 3.0, are shown in the table below.

Efficiency Standard for Dehumidifiers

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

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

9 Demand savings from Energy-Efficiency and DSM Rules for Pennsylvania‟s Alternative Energy Portfolio Standard Technical Reference Manual, September 7, 2005.

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

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 12
Source: US EPA

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

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

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
11-13-1	11/26/2013

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DISHWASHER

Measure Description

Residential dishwashers meeting the minimum qualifying efficiency standards established under the Energy Star Program. The dishwashers are assumed to be located within a residential unit and not in a commercial dishwasher foodservice application.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (\text{Deemed Annual Electric Energy Savings})$$

Peak Coincident Demand Savings

$$\Delta kW = units \times (\text{Deemed Peak Coincident Demand Savings}) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
$kWh_{wh\ gas}$	77 kWh	Deemed Annual Electric Energy Savings for gas water heater
$kWh_{wh\ electric}$	137 kWh	Deemed Annual Electric Energy Savings for electric water heater
kW_{dw}	0.0225 kW	Deemed Peak Coincident Demand Savings

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0

Baseline Efficiencies from which Savings are Calculated

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 11
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit savings taken from the Energy Star website, www.energystar.gov/index.cfm?c=dishwash.pr_crit_dishwashers

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0	10/15/2010

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REFRIGERATOR REPLACEMENT

Measure Description

Residential refrigerators and freezers include refrigerators, refrigerator-freezers, and freezers, such as standard-size residential units. Known collectively as "refrigeration products," these appliances chill and preserve food and beverages, provide ice and chilled water, and freeze food.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Early Replacement Baseline Refrigerator Energy Consumption

For the nameplate option, the formula is:

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

where:

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

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta therm$ = Annual gas energy savings
units = Number of measures installed under the program
$kWh_{DOE\ min}$ = Annual energy consumption of DOE minimally-compliant model most closely associated with the new refrigerator[11]

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[11] 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,

kWh_{ee} = Annual energy consumption/nameplate rating for the new CEE Tier 2 or Tier 3 model
CF = Coincidence factor
$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor at utility summer peak hour
$HVAC_g$ = HVAC interaction factor for annual natural gas consumption
8,760 = Hours in one year
F_{occ} = Occupant adjustment factor
F_{market} = Market adjustment factor

Summary of Variables and Data Sources

Variable	Value	Notes
F_{age}	1.0	Age factor for refrigerators that are nine years old or newer
F_{age}	1.1	Age factor for refrigerators between 9 and 14 years old
F_{age}	1.15	Age factor for refrigerators older than 14 years old
F_{seal}	1.0	Seal factor for intact seals
F_{seal}	1.05	Seal factor for deteriorated seals
$kWh_{baseline}$	695 kWh/year	for Con Edison and O&R territories
$kWh_{baseline}$	595 kWh/year	All other service territories
F_{market}		Market effects factor

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

Occupant Adjustment Factor (F_{occ})

The occupant adjustment factor[12] 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

used in this calculation. 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

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

Market Effects Factor (F_{market})

An adjustment factor must be applied to account for existing refrigerators that enter the used appliance market when programs do not have a recycling or old refrigerator-disabling component. The market effects factor is defined below.

Program Component	F_{market}
No recycling or disabling of existing refrigerators	0.8
Recycling or disabling of existing refrigerators can be demonstrated	1.0

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0

Baseline Efficiencies from which Savings are Calculated

Normal Replacement Baseline Refrigerator Energy Consumption

Energy consumption for the normal replacement baseline refrigerator shall be determined from the Federal Standard (NAECA) maximum consumption for the type and size of refrigerator purchased. These data are available in the directory of Energy Star qualified refrigerators on the Energy Star website[13] according to the make and model of the new (replacement) refrigerator.

Efficient Refrigerator Energy Consumption

Annual energy consumption for the new (replacement) refrigerator shall be determined from the DOE rating for the make and model number of the replacement unit. All new units shall be Energy Star qualified. These data are available in the directory of Energy Star qualified refrigerators on the Energy Star website according to the make and model of the replacement refrigerator.

Compliance Efficiency from which Incentives are Calculated

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[14] 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.[15] The calculations are shown below:

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.[16] The first is measuring/metering actual energy

[13] See list of qualified refrigerators on the Energy Star website: www.energystar.gov

[14] 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

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

[16] See Order Approving Modifications to the Technical Manual, Case 07-M-0548, July 18, 2011, pp. 18 – 20. In a unique provision to facilitate PA benefit cost analysis, the order provides a $75 default incremental cost for normal replacement of multi-family refrigerators, allowing use of a lesser value, not

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.

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:

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

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.

Effective Useful Life (EUL):

Years: 17
Source: NYS DPS

Ancillary Fossil Fuel Savings Impacts

Efficient refrigerators reject less heat into the conditioned space, which must be made up by the space heating system, resulting in HVAC interactions, which 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.

Ancillary Electric Savings Impacts

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

less than $35, if documented. Although refrigerators in single-family homes tend to be larger than those in multi-family housing, $75 may still be used as the incremental cost for normal replacement.

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.

Record of Revision

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

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APPLIANCE – CONTROL
*(*place-holder*)*

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APPLIANCE RECYCLING

AIR CONDITIONER – ROOM (RAC) RECYCLING

Measure Description

A consumer product, other than a "packaged terminal air conditioner," which is powered by a single-phase electric current and is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilating and heating.[17]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{\overline{EER}_{baseline}} - \frac{12}{\overline{EER}_{ee}} \times F_{repl} \right) \times EFLH_{cooling}$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
$EFLH_{cooling}$	= Cooling equivalent full-load hours
$\overline{EER}$	= Seasonal average energy efficiency ratio over the cooling season BTU/watt-hour, (used for a particular climate/building)
CF	= Coincidence factor
F_{repl}	= Fraction of the recycled units that are replaced with a new unit
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure

[17] Energy Star® Program Requirements, Product Specification for Room Air Conditioners, Eligibility Criteria Version 3.1

12 = kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application, use 0.7 as default.
EER	$\overline{EER}$	The EER is the DOE rated full-load efficiency of the unit, which is used to estimate the both the seasonal and peak efficiency of the unit.
$\overline{EER}_{baseline}$	7.7	Typical for units replaced
$\overline{EER}_{ee}$	9.8	Federal standard; consistent with 0.7 ton size
$EFLH_{cooling}$		Cooling equivalent full-load hours based on region, see Operating Hours below.
F_{repl}	0.76	Replacement factor based on a study of room air conditioner recycling conducted in Connecticut by Nexus Market Research and RLW Analytics.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Replacement factor (F_{repl})

The replacement factor is used to adjust the savings to account for the fraction of recycled units that are replaced with a new unit. The recommended value for the replacement factor is 0.76.

Baseline Efficiencies from which Savings are Calculated

Only air conditioners that are 5 years old or older are eligible for savings claims. Units from 5 to 10 years old will be treated as early replacements and use the existing unit as the baseline.

Units greater than 10 years old will be considered normal replacements and use a unit minimally compliant with Federal appliance standards (NAECA) as the baseline.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Residential room air conditioner cooling equivalent full load hours based on region.

City	$EFLH_{cooling}$
Albany	181
Binghamton	120
Buffalo	151
Massena	143
NYC	382
Poughkeepsie	208
Syracuse	186

Effective Useful Life (EUL)

Years: 3

Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. EFLH taken from Coincidence Factor Study Residential Room Air Conditioners, conducted by RLW Analytics, 2008.
    a. neep.org/.../2008-6-23_Final_Report_Coincidence_Factor_Study_Residential_Room_Air_Conditioners_SPWG.pdf
2. Replacement factor taken from the Nexus Market Research. December 2005. Impact Process and Market Study of the Connecticut Appliance Retirement Program: Overall Report. Cambridge, Mass.: Nexus Market

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
7-13-37	7/31/2013

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REFRIGERATOR AND FREEZER RECYCLING

Measure Description

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 electric grid.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (\text{Deemed Annual Electric Energy Savings})$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
TAF	= Temperature Adjustment Factor
LSAF	= Load Shape Adjustment Factor
8,760	= Hours in one year

Summary of Variables and Data Sources

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

potential variance within each of the key estimation variables.
These conditions, along with the lack of historic evaluation data on recycled units from New York homes require that the savings estimates presented in this Tech Manual be based on evaluations from other states. Once the evaluation efforts for the programs operated in New York have been completed the savings projections in this Tech Manual will be updated to reflect the findings from these new studies. At the current time, the savings from refrigerators and freezers in New York are based on the most recent study of these same programs in California. The California study employed on-site examinations and metering of units in addition to a comprehensive battery of participant questions identifying how the units were used.

The following deemed energy impact estimates shall be used in New York for refrigerator and freezer recycling programs[18] until this Tech Manual is updated with values calibrated to the programs operating in New York.

Variable	Value	Notes
TAF	1.22	Temperature adjustment factor for upstate NY
TAF	1.26	Temperature adjustment factor for downstate
LSF	1.06	Load shape adjustment factor
kWh for Primary Refrigerator	670	Deemed Annual Electric Energy Savings
kWh for Secondary Refrigerator	1,655	Deemed Annual Electric Energy Savings
kWh for Freezer	1,257	Deemed Annual Electric Energy Savings

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0

Baseline Efficiencies from which Savings are Calculated

The savings calculations apply to recycling of a functioning primary[19] or secondary refrigerator or freezer.

Compliance Efficiency from which Incentives are Calculated

The above listed deemed energy impact estimates shall be used in New York for refrigerator and freezer recycling programs[20].

Operating Hours

The operating hours for a secondary refrigerator or freezer are assumed to be a continuous 8,760 hours per year.

[18] See table 2-6 in the Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Program, April 2008, ADM Associates.
[19] Savings can be claimed for recycling a primary refrigerator as long as savings for that replacement were not claimed by another energy efficiency program.
[20] See table 2-6 in the Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Program, April 2008, ADM Associates.

Effective Useful Life (EUL), for Refrigerator recycling

Years: 5
Source: DEER

Effective Useful Life (EUL), for Freezer recycling

Years: 4
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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.

Record of Revision

Record of Revision Number	Issue Date
2	10/15/2010
7-13-4	7/31/2013
9-13-2	9/2/2013

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BUILDING SHELL

AIR LEAKAGE SEALING

Measure Description

Reduction in the natural infiltration rate of the home through sealing air leaks in the building envelope. These algorithms are used for single-family and smaller multi-family buildings where the use of a blower door is feasible. An alternate method for estimating savings that is based on the building‟s heated square footage is also provided for larger multi-family buildings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

(with blower door test)

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\frac{\Delta CFM_{50}}{n - factor}\right) \times \left(\frac{\Delta kWh}{CFM}\right) \times \left(\frac{SEER_{baseline}}{SEER_{part}}\right) \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{\Delta CFM_{50}}{n - factor}\right) \times \left(\frac{\Delta kW}{CFM}\right) \times \left(\frac{EER_{baseline}}{\overline{EER}_{part}}\right) \times \left[\frac{\eta_{dist,pk,baseline}}{\eta_{dist,pk,part}}\right]_{cooling} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{\Delta CFM_{50}}{n - factor}\right) \times \left(\frac{\Delta therm}{CFM}\right) \times \left(\frac{AFUE_{baseline}}{AFUE_{part}}\right) \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{heating}$$

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

Annual Electric Energy Savings

$$\Delta kWh = units \times floor\ area\ (1{,}000\ ft^2) \times \left(\frac{\Delta kWh}{1000\ ft^2}\right)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times floor\ area\ (1{,}000\ ft^2) \times \left(\frac{\Delta kW}{1000\ ft^2}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therm = units \times floor\ area\ (1{,}000\ ft^2) \times \left(\frac{\Delta therm}{1000\ ft^2}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherm	= Annual gas energy savings
units	= Number of measures installed under the program
AFUE	= Annual fuel utilization efficiency
CFM	= Cubic feet per minute
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
EER	= Energy efficiency ratio under peak conditions
$\overline{EER}$	= Seasonal average energy efficiency ratio over the cooling season BTU/watt-hour, (used for a particular climate/building)
CF	= Coincidence factor
n-factor	= Correction factor
η	= Energy efficiency (0 -100%)
$\bar{\eta}$	= Average energy efficiency (0 -100%)
part	= Participant
dist	= Distribution
pk	= Peak
baseline	= Baseline condition or measure
Δ	= Change, difference, or savings
ft^2	= Square foot
floor area	= Conditioned floor area

Summary of Variables and Data Sources

Variable	Value	Notes
Floor area		From application
ΔCFM_{50}		change in infiltration rate (cfm) at measured 50 Pa
ΔkWh/CFM		From prototype simulations, HVAC type weighted average by city. Use actual CFM_{50} reduction from blower door test.
ΔkW/CFM		From prototype simulations, HVAC type weighted average by city. Use actual CFM_{50} reduction from blower door test.
Δtherm/CFM		From prototype simulations, HVAC type weighted average by city. Use actual CFM_{50} reduction from blower door test.
n-factor	15	2 story home with normal wind exposure in NY climate

$1{,}000ft^2$		1,000 ft^2 of conditioned floor area
$\Delta kWh/1{,}000ft^2$		From prototype simulations, Vintage and HVAC type weighted average by city.
$\Delta kW/1{,}000ft^2$		From prototype simulations, Vintage and HVAC type weighted average by city.
Δ $therm/1{,}000ft^2$		From prototype simulations, Vintage and HVAC type weighted average by city.
$EER_{baseline}$	11.1	
$\overline{EER}_{part}$		Participant population average, defaults to $EER_{baseline}$ (no adjustment)
$SEER_{baseline}$	13	
$SEER_{part}$		Participant population average, Defaults to $SEER_{baseline}$ (no adjustment)
$AFUE_{baseline}$	78%	
$AFUE_{part}$		Participant population average, Defaults to $AFUE_{baseline}$ (no adjustment)
$\overline{\eta}_{dist,\ baseline}$	0.956	
$\overline{\eta}_{dist,\ part}$		Distribution system efficiency under peak conditions within participant population, participant population average defaults to $\overline{\eta}_{dist,\ baseline}$.(no adjustment)
$\eta_{dist,\ pk,\ baseline}$	0.956	Distribution system efficiency under peak conditions used in simulation
$\eta_{dist,\ pk,\ part}$		Participant population average, defaults to $\eta_{dist,\ pk,\ baseline}$ (no adjustment)

Unit energy and demand savings calculated from the building prototype simulation models are shown in Appendix E. The savings normalized to infiltration rate reduction are tabulated by building type, location, and HVAC system type. The savings normalized per square foot of floor area are tabulated by building type, vintage, and HVAC system type.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Baseline natural infiltration rate is assumed be one air change per hour (ACH) for old vintage homes, and 0.5 ACH for average vintage homes.

Compliance Efficiency from which Incentives are Calculated

See Appendix E.

Operating Hours

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

Effective Useful Life (EUL)

Years: 15
Source: GDS

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Correction for blower door infiltration rate to natural air changes based on relationships from Sherman, "Estimation of Infiltration for Leakage and Climate Indicators," Energy and Buildings, 10, 1987. Assumes a climate factor of 18.5 and a height correction factor of 0.8.
2. Typical values for demand coincidence factors (CF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA August, 1993.

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7-13-25	7/31/2013

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Hot Water Pipe Insulation

Measure Description

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 Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times L \times \frac{\left[(UA/L)_{baseline} - (UA/L)_{ee}\right]}{\eta_h \times 3{,}412} \times \overline{\Delta T} \times hr$$

Peak Coincident Demand Savings

$$\Delta kW = units \times L \times \frac{\left[(UA/L)_{baseline} - (UA/L)_{ee}\right]}{\eta_h \times 3{,}412} \times \Delta T \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times L \times \frac{\left[(UA/L)_{baseline} - (UA/L)_{ee}\right]}{\eta_h \times 100{,}000} \times \overline{\Delta T} \times hr$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
L	= Length
Δ	= Change, difference, or savings
T	= Temperature
$\overline{\Delta T}$	= Average temperature difference
baseline	= Baseline condition or baseline measure
ee	= Energy efficient
h	= Heater
UA/L	= Heat loss coefficient (BTU/hr-°F)
3,412	= Conversion factor, one kW equals 3,412.14 BTU/h
8,760	= Hours in one year
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU"s

Summary of Variables and Data Sources

Variable	Value	Notes
L	From application	Length of insulation installed
difference between water within the pipe and air under peak conditions;		
ΔT	60°F (service hot water) 100°F (hot water heat) 130°F (steam heat)	Temperature difference between the hot water in the pipe and surrounding air temperature (°F); 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
average temperature(°F) difference between water within the pipe and air temperature;		
$\overline{\Delta T}$	60°F (service hot water) 100°F (hot water heat) 130°F (steam heat)	Average temperature difference between the hot water in the pipe and surrounding air temperature (°F); 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	Overall pipe heat loss coefficient per unit length (BTU/hr-°F-ft), value based on pipe size, insulation type and insulation thickness
η_h	0.97 (electric 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: $EFLH_{heating}$ (SF and MF low-rise) 3240 (MF high-rise)	$EFLH_{heating}$ from Appendix G.

Coincidence Factor (CF)

The recommended value for the coincidence factor for domestic water heating is 0.8.
The recommended value for the coincidence factor for hydronic space heating is 0.0.

Baseline Efficiencies from which Savings are Calculated

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

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.

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 multi-family 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.

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.

Operating Hours

The water heater is assumed to be available during all hours. Single-family and multi-family low-rise buildings should use the heating equivalent full-load hours as shown in Appendix G. Systems in high-rise multi-family buildings should use 3240 operating hours per year.

Effective Useful Life (EUL)

Years: 13, Electric water heater
Years: 11, Natural gas water heater
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. The uninsulated pipe losses were obtained from the 2001 ASHRAE Handbook of Fundamentals, Chapter 25, Tables 11A and 12.

Record of Revision

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1	10/15/2010
7-13-15	7/31/2013

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Opaque Shell Insulation

Measure Description

This measure 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 Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times ft^2 \times \left(\frac{\Delta kWh}{ft^2}\right) \times \left(\frac{SEER_{baseline}}{SEER_{part}}\right) \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{cooling}$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times ft^2 \times \left(\frac{\Delta therm}{ft^2}\right) \times \left(\frac{AFUE_{baseline}}{AFUE_{part}}\right) \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{heating}$$

where:

Δ kWh	= Annual electricity energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
ft^2	= Square foot
CF	= Coincidence factor
AFUE	= Annual fuel utilization efficiency
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
EER	= Energy efficiency ratio under peak conditions
$\bar{\eta}$	= Average energy efficiency (0 -100%)
η	= Energy efficiency (0 -100%)
dist	= Distribution
baseline	= Baseline condition or measure
part	= Participant

Summary of Variables and Data Sources

Variable	Value	Notes
ft^2		From application
$\Delta kWh / ft^2$		HVAC type weighted average by city based on the combination of the existing and installed R-value
$\Delta kW / ft^2$		HVAC type weighted average by city based on the combination of the existing and installed R-value
$\Delta therm / ft^2$		HVAC type weighted average by city based on the combination of the existing and installed R-value
$EER_{baseline}$	11.1	
EER_{part}		Participant population average defaults to $EER_{baseline}$ (no adjustment)
$SEER_{baseline}$	13	SEER used in the simulations
$SEER_{part}$		SEER of cooling system within participant population Participant population average defaults to $SEER_{baseline}$ (no adjustment)
$AFUE_{baseline}$	78%	AFUE of heating system within participant population. AFUE used in the simulations
$AFUE_{part}$		Participant population average. Defaults to $AFUE_{baseline}$ (no adjustment)
$\bar{\eta}_{dist,\ baseline}$	0.956	Distribution system seasonal efficiency used in simulations
$\bar{\eta}_{dist,\ part}$		Distribution system seasonal efficiency within participant population. Participant population average defaults to $\bar{\eta}_{dist,\ baseline}$ (no adjustment)
$\eta_{dist,\ pk,\ baseline}$	0.956	Distribution system efficiency under peak conditions used in simulation
$\eta_{dist,\ pk,\ part}$		Distribution system efficiency under peak conditions within participant population. Participant population average defaults to $\eta_{dist,\ pk,\ baseline}$ (no adjustment)

Unit energy and demand savings calculated from the building prototype simulation models are shown in Appendix E. The savings are tabulated by building type and HVAC system type across a range of pre-existing (baseline) and upgraded insulation R-values.

These values can be adjusted to account for heating and cooling system efficiencies that vary from the values used in the simulations. In the absence HVAC system or distribution system efficiency data, no adjustment is made.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Energy savings over a variety of baseline wall and ceiling insulation levels are listed in Appendix E. The baseline R-value must be captured in the program application. Interpolation of the data in Appendix E is permitted.

Compliance Efficiency from which Incentives are Calculated

Energy savings over a variety of measure wall and ceiling insulation levels are listed in Appendix E. The installed R-value must be captured in the program application. Interpolation of the data in Appendix E is permitted. Note: The data in Appendix E represent the total R-value of the existing plus added insulation.

Operating Hours

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

Effective Useful Life (EUL)

Years: 30
Source: Energy Trust of Oregon, Inc.

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Typical values for coincidence factors (CF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA August, 1993.

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7-13-25	7/31/2013
7-13-38	7/31/2013

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

Measure Description

A rigid, insulated cover, installed on the inside of a window or through-the-wall room air conditioning (RAC) 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

Annual Electric Energy Savings = N/A

Peak Coincident Demand Savings = N/A

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{1.08 \times CFM \times HDD \times 24\ hrs/day}{HPs}\right) / 100{,}000$$

where:

Δ kWh = Annual electricity energy savings
Δ kW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
1.08 = Specific heat of air × density of inlet air @ 70^{o}F × 60 min/hr
CFM = Cubic foot per minute
HDD = Heating degree day
HPs = Heating plant seasonal efficiency
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU‟s

Summary of Variables and Data Sources

Variable	Value	Notes
Low-End Estimate at 5 Pa Indoor-Outdoor Pressure Differential	23	Annual Deemed Energy Savings Values (therms), for New York City
High-End Estimate at 10 Pa Indoor-Outdoor Pressure Differential	32	Annual Deemed Energy Savings Values (therms), for New York City
Indoor-Outdoor Pressure Differential	28	When indoor-outdoor pressure differential is not known, use the rounded average of 28 therms.
Heating plant seasonal efficiency, HPs	0.70	This value used in Urban Green Building Council study[1].
HDD	4,500	NYC Climate

Variable	Value	Notes
CFM low end	13	Field tested leakage at 5 Pa indoor-outdoor differential pressure
CFM high end	19	Field tested leakage at 10 Pa indoor-outdoor differential pressure

Note: Pa = Pascal, the standard unit of pressure or stress in the International system of units (SI)

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.

Baseline Efficiencies from which Savings are Calculated

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 5
Source: Window Sentry

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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

Record of Revision Number	Issue Date
6-14-1	6/19/2014

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WINDOW REPLACEMENT

Measure Description

Energy Star® windows with reduced thermal conductance and solar heat gain coefficient are an assembled unit consisting of a frame/sash component holding one or more pieces of glazing functioning to admit light and/or air into an enclosure and designed for a vertical installation in an external wall of a residential building.[21]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times area_g/100ft^2 \times \left(\frac{\Delta kWh}{100ft^2}\right) \times \left(\frac{SEER_{baseline}}{SEER_{part}}\right) \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{cooling}$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = units \times area_g/100ft^2 \times \left(\frac{\Delta therm}{100ft^2}\right) \times \left(\frac{AFUE_{baseline}}{AFUE_{part}}\right) \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{heating}$$

where:

Δ kWh	= Annual electricity energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
therm	= Unit of heat
Δ	= Change, difference, or savings
units	= Number of measures installed under the program
area	= Extent of space or surface
ft^2	= Square foot
EER	= Energy efficiency ratio under peak conditions
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
AFUE	= Annual fuel utilization efficiency
CF	= Coincidence factor
cooling	= Cooling
heating	= Heating

[21] ENERGY STAR Program Requirements for Residential Windows, Doors, and Skylights: Version 5.0 (April 7, 2009)

g	= Glazing
baseline	= Baseline condition or baseline measure
part	= Participant
dist	= Distribution
η	= Energy efficiency (0 -100%)
$\overline{\eta}$	= Average energy efficiency (0 -100%)

Summary of Variables and Data Sources

Variable	Value	Notes
g		Glazing area from application
ΔkWh/100SF		HVAC type weighted average by city, use existing window type or vintage default for baseline.
ΔkW/100SF		HVAC type weighted average by city, use existing window type or vintage default for baseline.
Δtherm/100SF		HVAC type weighted average by city, use existing window type or vintage default for baseline.
$EER_{baseline}$	11.1	EER used in the simulations
EER_{part}		EER of cooling systems within participant population, average defaults to EER_{base} (no adjustment)
$SEER_{baseline}$	13	SEER used in the simulations
$SEER_{part}$		SEER of cooling system within participant population, average defaults to $SEER_{base}$ (no adjustment)
$AFUE_{baseline}$	78%	AFUE used in the simulations
$AFUE_{part}$		AFUE of heating system within participant population, average defaults to $AFUE_{base}$ (no adjustment)
$\overline{\eta}_{dist,baseline}$	0.956	Distribution system seasonal efficiency used in simulations
$\overline{\eta}_{dist,part}$		Distribution system seasonal efficiency within participant population, average defaults to $\overline{\eta}_{dist,baseline}$ (no adjustment)
$\eta_{dist,pk,baseline}$	0.956	Distribution system efficiency under peak conditions used in simulation
$\eta_{dist,pk,part}$		Distribution system efficiency under peak conditions within participant population, average defaults to $\eta_{dist,pk,baseline}$ (no adjustment)

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

A variety of existing window combinations are shown in the unit savings tables, including single pane clear glass with a solar heat gain coefficient of 0.87 and U-value of 0.93 BTU/hr-SF-^{o}F , double pane clear glass with a solar heat gain coefficient of 0.62 and U-value of 0.55 BTU/hr-SF-^{o}F, and a minimally code compliant window with a solar heat gain coefficient of 0.34 and U-value of 0.35 BTU/hr-SF-^{o}F. Energy savings are estimated based on the characteristics of the existing window. Single pane clear glass is the default for the old vintage, while double pane clear glass is the default for the average vintage. The minimally code compliant window is assumed to be the base case for new construction or window replacement projects.

A typical window meeting the current Energy Star specifications is assumed to be the installed measure. The solar heat gain coefficient is assumed at 0.34 with a U-value of 0.30 BTU/hr-ft^2- ^{o}F.

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

Compliance Efficiency from which Incentives are Calculated

These measures must meet the product criteria as listed in the ENERGY STAR® Eligibility Criteria for Residential Windows, Doors, and Skylights, version 5.0, effective date January 4, 2010.

Operating Hours

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

Effective Useful Life (EUL)

Years: 20
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Window properties, for baseline windows, taken from 2009 ASHRAE Handbook of Fundamentals, Chapter 15.
2. Typical values for coincidence factors (CF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA. August 1993.

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010

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DOMESTIC HOT WATER

DOMESTIC HOT WATER TANK BLANKET

Measure Description

Insulation blankets installed around a domestic hot water storage-type water heater can reduce the stand by heat losses of the tank.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{(UA_{baseline} - UA_{ee}) \times \overline{\Delta T}}{3{,}412 \times \eta_{elec}} \times 8{,}760$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therm = units \times \frac{(UA_{baseline} - UA_{ee}) \times \overline{\Delta T}}{\eta_{gas}} \times \frac{8{,}760}{100{,}000}$$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
UA	= Overall heat transfer coefficient (BTU/hr-°F)
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
ΔT	= Temperature difference between storage tank set point temperature and surrounding air ambient temperature (°F)
$\overline{\Delta T}$	= Average temperature difference between storage tank set point temperature and surrounding air ambient temperature (°F)
CF	= Coincidence factor
3,412	= Conversion factor, one kW equals 3,412.14 BTU/h
8,760	= Hours in one year
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU‟s

Summary of Variables and Data Sources

Variable	Value	Notes
$UA_{baseline}$		Overall heat transfer coefficient for baseline measure, lookup based on tank volume
UA_{ee}		Overall heat transfer coefficient for energy efficient measure, lookup based on tank volume
T_{set}	130	Set point temperature of storage tank (°F)
T_{amb}	67.5	Ambient temperature of surrounding air (°F)
ΔT	T_{set} - T_{amb}	Temperature difference between the water inside the tank and the ambient air (°F)
$\overline{\Delta T}$	T_{set} - T_{amb}	Average temperature difference between the water inside the tank and the ambient air (°F)
η_{elec}	0.97	Electric water heater efficiency
η_{gas}	0.67	Natural gas water heater efficiency
Tank volume	50	Electric (default for SF and single unit MF, use application for central MF)
Tank volume	40	Gas (default for SF and single unit MF, use application for central MF)

The **overall heat transfer coefficient** for the base and improved (insulated) water heater assuming 1 inch of foam insulation in the existing water heater and an additional 2 inches of fiberglass insulation for the tank wrap are shown below. The tank wrap is assumed to cover the tank sides only. Water heater tank height and diameter in the table below were taken from a survey of manufacturers‟ literature for typical water heaters. Note, the radius of the bare tank is calculated from the radius of the finished tank (which is one-half of the diameter shown in the table below) less the insulation thickness.

UA Values for Single-family Residential Water Heaters

Water heater size (gal)	Height	Diameter	$UA_{baseline}$	UA_{ee}
30	60	16	4.35	1.91
40	61	16.5	4.58	2.00
50	53	18	4.49	1.96
66	58	20	5.51	2.39
80	58	22	6.18	2.67

UA Values for Larger Multi-Family Residential Water Heaters

Water heater size (gal)	Height (in)	Diameter (in)	$UA_{baseline}$ (BTU/hr- °F)				
			Bare tank	Fiberglass		Foam	
				1 in	2in	1 in	2in
120	61	24	40.6	10.0	5.1	7.9	4.1
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

Water heater size (gal)	Height (in)	Diameter (in)	$UA_{baseline}$ (BTU/hr- ^oF)				
			Bare tank	Fiberglass		Foam	
				1 in	2in	1 in	2in
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
1,000	138	48	177.9	43.5	22.1	34.6	17.6

Water heater size (gal)	Height (in)	Diameter (in)	UA_{ee} (BTU/hr- ^oF) with 2 in Fiberglass wrap				
			Bare tank	Fiberglass		Foam	
				1 in	2in	1 in	2in
120	61	24	5.1	3.8	2.7	3.4	2.4
140	76	24	6.2	4.6	3.3	4.1	2.9
200	72	30	7.6	5.6	4.0	5.0	3.5
250	84	30	8.6	6.3	4.6	5.7	4.0
350	88	36	11.0	8.1	5.7	7.2	5.0
400	97	36	11.9	8.7	6.2	7.8	5.4
500	74	48	13.3	10.2	6.9	8.9	6.0
750	106	48	17.7	13.2	9.2	11.7	8.0
1,000	138	48	22.1	16.1	11.5	14.4	10.0

The ambient temperature difference between the water heat set point and the ambient room temperature is used to calculate the standby 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.

Water heater size	**Electric water heater - 50 gal**	**Gas water heater – 40 gal**
$UA_{baseline}$	4.49	4.58
UA_{ee}	1.96	2.00
ΔT_s	60°F	60°F
ΔT	60°F	60°F
η	0.97	0.67
ΔkW	0.046	N/A
ΔkWh	402	N/A
Δtherm	N/A	18.1

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The $UA_{baseline}$ for existing water heaters were calculated assuming 1 inch of high-density polyurethane foam insulation as the factory standard insulation level. For an electric storage type water heater an efficiency of 0.97 is assumed. The combustion efficiency of 0.75 is assumed for a non-condensing natural gas fired storage type water heater.

Compliance Efficiency from which Incentives are Calculated

The UA_{ee} for wrapped water heaters were calculated assuming the tank wrap adds 2 inches of fiberglass insulation to the existing tank.

Operating Hours

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

Effective Useful Life (EUL)

Years: 10
Source: NYSERDA

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. The thermal conductivity of various tank insulation materials is available in the ASHRAE Handbook of Fundamentals (ASHRAE, 1989). The thermal conductivity of high-density polyurethane foam insulation is assumed to be 0.0167 BTU/hr-ft-°F and the thermal conductivity of fiberglass insulation is assumed to be 0.021 BTU/hr-ft-°F.

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
11-13-2	11/26/2013

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HEAT PUMP WATER HEATER (HPWH) -AIR SOURCE

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.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = units \times (\text{Deemed Peak Coincident Demand Savings}) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
GPD	= Average daily water consumption (gallons/day)
$\overline{\Delta T}$	= Average difference between hot water delivery temperature and the supply main temperature (°F)
EF	= Energy factor
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
3,412	= Conversion factor, one kW equals 3,412.14 BTU/h
8.33	= Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
365	= Days in one year

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkW	0.17	Deemed peak coincident demand savings[22]
$EF_{baseline}$		Energy factor for baseline appliance

[22] The reference for the deemed peak coincident savings value is "Field Testing of Pre-Production Prototype Heat Pump Water Heaters" Federal Energy Management Program, DOE/EE-0317, May 2007.

EF_{ee}		Energy factor for energy efficient appliance
GPD	78	Based on family of 4
$\overline{\Delta T}$	T_{set} - T_{main}	Average temperature difference between storage tank set point temperature and supply water temperature in water main (°F)
$EF_{baseline}$		Calculate from tank volume
EF_{ee}	2.2	
tank volume		From application
T_{set}	130	Temperature set point for water in tank
T_{main}		Temperature of water in supply water in main

The water temperature difference between the water heat set point and cold water mains temperature is used to calculate the hot water load. If the water heater has sufficient capacity to meet the load, hot water will be delivered at the water heater set point temperature. Water heater set point for residential buildings is usually in the range of 120°F to 140°F. The water heater set point should be consistent with temperature assumed in the water use data.

Supply water main temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Supply main temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature (°F)	T main (°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

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 in household	Gallons/person-day	Gallons/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. The energy factor for heat pump water heaters also takes into account the interactions between the heat pump water heater and the heating and cooling consumption in the home. The EF is developed for an average US home in an average US climate. Programs should use the manufacturers‟ rated EF until data can be developed that is more appropriate for NY climates.

Baseline Efficiencies from which Savings are Calculated

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.

The baseline energy factor ($EF_{baseline}$) 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:
$EF = 0.97 - 0.00132 \times v$

Gas water heaters:
$EF = 0.67 - 0.0019 \times v$

where:
v = tank volume in gallons

Coincidence Factor (CF)

The peak demand savings are included in the deemed savings values presented.

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.

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

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.

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-13-3	6/30/2013
11-13-2	11/26/2013

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INDIRECT WATER HEATER

Measure Description

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.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$\Delta kWh = N/A$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{\left(GPD \times 365 \times 8.33 \times \overline{\Delta T}\right)}{100{,}000} \times \left[\left(\frac{1}{Eff_{t,\ baseline}}\right) - \left(\frac{1}{Eff_{t,\ ee}}\right)\right] +$$

$$\left[\left(\frac{UA_{base}}{E_{t,\ base}}\right) - \left(\frac{UA_{ee}}{Eff_{t,\ ee}}\right)\right] \times \left(\frac{\Delta T}{100{,}000}\right) \times 8{,}760$$

when:

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

and:

$EF_{baseline} = 0.67 - 0.0019 \times v_{baseline}$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
GPD	= Gallons per day
$\overline{\Delta T}$	= Average temperature difference between the cold inlet temperature and the hot water delivery temperature (°F)

ΔT	= Temperature difference between the cold inlet temperature and the hot water delivery temperature (°F)
EF	= Energy factor
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
$UA_{baseline}$	= 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)
GPD	= Average daily water consumption (gallons/day).
$EF_{baseline}$	= Baseline storage water heater energy factor
$Efft_{t, ee}$	= Energy efficient indirect water heater boiler thermal efficiency
$Efft_{baseline}$	= Baseline water heater efficiency (= $RE_{baseline}$ if tank type baseline; $E_{t, baseline}$ if indirect baseline)
$RE_{baseline}$	= Tank type water heater recovery efficiency
$Cap_{baseline}$	= Tank type water heater capacity (BTU/hr)
$v_{baseline}$	= Tank type water heater capacity (gallons)
8.33	= Energy required (BTU"s), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU"s
365	= Days in one year
8,760	= Hours in one year
0.000584	= Conversion factor used in DOE testing procedure
0.0019	= Natural gas efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume

Summary of Variables and Data Sources

Variable	Value	Notes
$UA_{baseline}$		Calculation from baseline water heater EF or standby loss.
UA_{ee}		Calculation from lookup table based on tank volume and insulation thickness, use 1 inch if insulation thickness not known.
ΔT	$T_{set} - T_{amb}$	Temperature difference in degrees Fahrenheit, between the stored hot water and the surrounding air.
GPD		Default to 78 for single-family. Use GPD based on number of units for multi-family; otherwise from application
$\overline{\Delta T}$		Average difference between the cold inlet temperature and the hot water delivery temperature (°F)
ΔT	$T_{set} - T_{main}$	Temperature difference between tank set point and water main temperature (°F)
$Eff_{t, baseline}$	0.75 (gas)	Thermal efficiency of baseline unit
$Eff_{t, ee}$		Thermal efficiency of energy efficient measure, from application
v		Volume from application
T_{set}	130	Temperature set point of water in tank (°F)
T_{amb}	67.5	Ambient temperature of air surrounding tank (°F)
T_{main}		Average T_{main} based on upstate or downstate (°F)
Capacity (Q)	40,000	See table for storage type gas water heaters

Variable	Value	Notes
$EF_{baseline}$		Energy factor of baseline unit, calculate from tank volume
$RE_{baseline}$		Recovery efficiency of baseline unit, 0.75
$v_{baseline}$		Volume of baseline unit, from application
$SL_{baseline}$	380 BTU/hr	Standby heat loss, based on 120 gal tank with 2 in foam insulation

The ambient temperature difference between the water heat set point and the ambient room temperature is used to calculate the standby losses. Water heaters are generally located in conditioned or partially conditioned spaces to avoid freezing. A room temperature of 67.5°F[23] is the nominal default value.

The water temperature difference between the water heat set point and cold water main temperature is used to calculate the hot water load. If the water heater has sufficient capacity to meet the load, hot water will be delivered at the water heater set point temperature. Water heater set point for residential buildings is usually in the range of 120°F to 140°F. The water heater set point should be consistent with temperature assumed in the water use data.

Cold water entering temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature (°F)	T main (°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

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

[23] Energy Conservation Program for Consumer Products: test procedure for water heaters, 10 CFR Part 430, nominal value, Federal Register Vol. 63, no.90/May 11, 1998, page 26014

Number of people	Gal/person-day	Gal/day-household
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.

Standard assumptions for recovery efficiency and input capacity for small non-condensing natural gas water heaters, values applicable to non-condensing water heaters with EF≤ 0.68:

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

Tank overall heat loss coefficient (UA) 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:

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

where:
RE = Recovery Efficiency
Cap = Water Heater Capacity
EF = Energy Factor
67.5 = Room air temperature during DOE testing procedure
0.000584 = Conversion factor used in DOE testing procedure

UA values for typical natural gas water heaters:

Water Heater Size (Gals)	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.

$$UA = SL / (70\ BTU/hr - °F)$$ `

where:

UA = Tank overall heat loss coefficient
SL = Standby loss (BTU/hr)
70 =Temperature difference associated with standby loss specification (^oF)

UA values for indirect water heater tanks are estimated from the tank physical size and insulation type and thickness.

$$UA_{baseline} = \left[\frac{(2 \times \pi \times k_{side} \times ht)}{\ln(r_2/r_1)}\right] + \left[\frac{(\pi \times r_1^2 \times k_{bot})}{th_{bot}}\right] + \left[\frac{(\pi \times r_1^2 \times k_{top})}{th_{top}}\right]$$

where:
$UA_{baseline}$ = Baseline tank overall heat loss coefficient
k_{side} = Thermal conductivity of tank sidewall insulation (BTU/hr-ft-°F)
k_{bot} = Thermal conductivity of tank bottom insulation (BTU/hr-ft-°F)
k_{top} = Thermal conductivity of tank top insulation (BTU/hr-ft-°F)
k_{wrap} = Thermal conductivity of tank wrap (BTU/hr-ft-°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)
ht = 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 single-family residential indirect water heater tanks:

Volume (gal)	Height (bare tank) inches	Diameter (bare tank) inches	Insulation	UA (BTU/hr- ^oF)
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

UA values for typical multi-family residential indirect water heater tanks:

Water heater size (gal)	**Height (in)**	**Diameter (in)**	**UA (BTU/hr- ^oF)**				
				Fiberglass		**Foam**	
			Bare tank	**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
1,000	138	48	177.9	43.5	22.1	34.6	17.6

For multi-family units, baseline thermal efficiency for gas water heaters is assumed to be 0.75. Baseline thermal efficiency for existing boilers is 0.75. Note: combustion efficiency (E_c) may be substituted for thermal efficiency if thermal efficiency is not known.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Incentives are Calculated

The baseline assumption for indirect water heaters is a standard efficiency tank type water heater or an indirect system with a baseline efficiency boiler. The baseline energy factor ($EF_{baseline}$) is as follows: For 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:

$EF_{baseline}$ = Energy factor of baseline measure
v = Volume
0.67 = Natural gas water heater Energy Factor
0.0019 = Natural gas efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Water heater assumed to be available at all hours.

Effective Useful Life (EUL)

Years: 13
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Reduction in standby heat losses will have a small impact on space heating and cooling when the water heater is located in conditioned space and not included in these calculations.

Ancillary Electric Savings Impacts

References

1. DOE test procedure for measure is from 10 CFR Part 430, Energy Conservation Program for Consumer Products: Test Procedures for Water Heaters Final Rule, Federal Register 63 (90): 25995–26016. 11 May 1998. Retrieved March 26, 2013.

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
6-13-2	6/30/2013
7-13-5	7/31/2013
7-13-6	7/31/2013
7-13-29	7/31/2013
7-13-33	7/31/2013
7-13-34	7/31/2013
7-13-35	7/31/2013
11-3-2	11/26/2013

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STORAGE TANK AND INSTANTANEOUS DOMESTIC WATER HEATER

Measure Description[24]

Storage tank-type water heater, are units designed to heat and store water at a thermostatically controlled temperature of less than 180 °F, including: gas storage water heaters with a nominal input of 75,000 British thermal units (BTU) per hour or less and having a rated storage capacity of not less than 20 gallons nor more than 100 gallons; electric heat pump type units with a maximum current rating of 24 amperes at an input voltage of 250 or less, and, if the tank is supplied, having a manufacturer‟s rated storage capacity of 120 gallons or less.

Instantaneous water heater, tankless, are units which initiate heating based on sensing water flow and deliver water at a controlled temperature of less than 180 °F, heat water but contain no more than one gallon of water per 4,000 BTU per hour of input, including: gas instantaneous water heaters with an input between 50,000 BTU/h but less than 200,000 BTU per hour and has a manufacturer‟s specified storage capacity of less than 2 gallons.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

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

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
UA	= Overall heat transfer coefficient (BTU/hr-°F)

[24] Based on definition found in Federal Register 10 CFR 430, subpart B, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water.

baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
ΔT	= Temperature difference between storage tank set point temperature and surrounding air ambient temperature (^oF)
$\overline{\Delta T}$	= Average temperature difference between storage tank set point temperature and surrounding air ambient temperature (^oF)
CF	= Coincidence factor
EF	= Energy factor
GPD	= Gallons per day
3,412	= Conversion factor (BTU/kWh), one kWh equals 3,412 BTU"s
8.33	= Energy required (BTU"s), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU"s
365	= Days in one year

Summary of Variables and Data Sources

Variable	Value	Notes
$UA_{baseline}$		Overall heat transfer coefficient for baseline measure, lookup based on tank volume
UA_{ee}		Overall heat transfer coefficient for energy efficient measure, lookup based on tank volume
ΔT	T_{set} - T_{amb}	Temperature difference between the water inside the tank and the ambient air
GPD	78	Default for single-family, use GPD based on number of units for multi-family.
ΔT	$T_{set} - T_{main}$	Temperature difference between the water inside the tank and the temperature in the supply main (^oF)
$\overline{\Delta T}$	$T_{set} - T_{main}$	Average temperature difference between the water inside the tank and the temperature in the supply main (^oF)
$EF_{baseline}$		Energy factor for baseline unit, calculate from tank volume and fuel type
EF_{ee}		Energy factor of energy efficient measure, from application
v		Water tank volume from application
T_{set}	130	Set point temperature of storage tank
T_{amb}	67.5	Ambient temperature of surrounding air
T_{main}		Average T_{main} based on upstate or downstate
Capacity	15,400	Electric (Default for SF and single unit MF, use application for central MF)
	40,000	Gas (Default for SF and single unit MF, use application for central MF)

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Savings are Calculated

The ambient temperature difference between the water heat set point and the ambient room temperature is used to calculate the standby 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.

The water temperature difference between the water heat set point and cold water main temperature is used to calculate the hot water load. If the water heater has sufficient capacity to meet the load, hot water will be delivered at the water heater set point temperature. Water heater set point for residential buildings is usually in the range of 120°F to 140°F. The water heater set point should be consistent with temperature assumed in the water use data.

Cold water entering temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature (°F)	T main (°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

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

Standard assumptions for recovery efficiency and input capacity for non-condensing water heaters[25] are:

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

Tank overall heat loss coefficient (UA[26]) 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:

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

where:

RE = Recovery Efficiency
Cap = Water Heater Capacity
EF = Energy Factor
baseline = Baseline condition or measure
67.5 = Room air temperature during DOE testing procedure
0.000584 = Conversion factor used in DOE testing procedure

UA values for typical natural gas water heaters:

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

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

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.

The baseline energy factor ($EF_{baseline}$) for 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:

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25 Values applicable to non-condensing water heaters with EF ≤ 0.68.

26 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.

Baseline energy factor ($EF_{baseline}$)

Electric water heaters:

$EF = 0.97 - 0.00132v$

Natural gas water heaters:

$EF = 0.67 - 0.0019v$

where:

EF	= Energy factor
v	= Tank volume in gallons
0.00132	= Electric efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.
0.97	= Energy factor for electric water heater
0.67	= Energy factor for gas water heater
0.0019	= Natural gas efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.

Compliance Efficiency from which Incentives are Calculated

Compliance efficiency for a natural gas storage tank water heater, EF = 0.67
Compliance efficiency for a electric resistance storage tank water heater, EF = 0.97
Compliance efficiency for an instantaneous natural gas water heater, EF = 0.82

Operating Hours

Water heater assumed to be available at all hours.

Effective Useful Life (EUL)

Years: 15 – Storage tank type
Years: 20 - Instantaneous
Source: DEER

Ancillary Fossil Fuel Savings Impacts

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.

Ancillary Electric Savings Impacts

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.

Record of Revision

Record of Revision Number	Issue Date
1	10/15/2010
6-13-1	6/30/2013
7-13-6	7/31/2013
11-13-2	11/26/2013

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DOMESTIC HOT WATER – CONTROL

FAUCET – LOW FLOW AERATOR

Measure Description

A faucet aerator is a water saving device that, by federal guidelines that went into effect in 1994, enables no more than 2.2 gallons per minute (gpm) to pass through the faucet. A low flow faucet aerator can reduce water flow to 1.5 gpm while maintaining appropriate water pressure and flow.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times [(H_2O_{savings} \times (T_{faucet} - T_{wh}) \times \left(\frac{8.33}{3{,}412}\right)] / EF_{elec}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times [(H_2O_{savings} \times (T_{faucet} - T_{wh}) \times \left(\frac{8.33}{100{,}000}\right) / EF_{gas}$$

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

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
EF	= Energy factor
$H_2O_{savings}$	= Water savings
GPM	= Gallon per minute
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
$Flow_r$	= Flow rate restricted
T	= Temperature (^oF)
8.33	= Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
365	= Days in one year
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU‟s
3,412	= Conversion factor, one kW equals 3,412.14 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}	1.5	Gallons per minute for energy efficient measure, from application
$GPM_{baseline}$	2.2	Gallons per minute for baseline measure
$Flow_r$	0.75	Flow restriction factor of faucet aerator
minutes/use	0.5	Assumed duration of use
uses/day	30	Assumed number of uses per day
365	365	Days per year of use
$H_2O_{savings}$	3,830	Calculated gallons of water saved per year based on installation of energy efficient measure
T_{faucet}	80	The typical water temperature leaving the faucet in ^oF
T_{main}		Average inlet water temperature (see appending table) (^oF)
$EF_{electric}$	0.97	Electric water heater efficiency, per Energy Conservation Construction Code of NYS
EF_{gas}	0.67	Natural gas water heater efficiency, per Energy Conservation Code of NYS

Inlet water temperature from main, by location is shown below.

City	Annual average outdoor temperature (°F)	T main (°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

The Summary of Variables and Data Sources provides the baseline (standard) and low flow aerator water flows, related input assumptions, and the resulting water savings. Assumptions regarding average duration of use and number of uses per day are also presented. This is based on the CL&P and UI savings document, which itself relied on FEMP assumptions.[27]

Compliance Efficiency from which Incentives are Calculated

[27] Federal Energy Management Program "Domestic Water Conservation Technologies" at www1.eere.energy.gov/femp/pdfs/22799.pdf and other sources.

Operating Hours

Operating hours are assumed at 365 days per year

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Methodology derived from CL&P and UI Program Savings Documentation for 2008 Program Year, pp. 157-158.
2. See Federal Energy Management Program "Domestic Water Conservation Technologies" for water savings data. www1.eere.energy.gov/femp/pdfs/22799.pdf
3. 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
4. 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.

Record of Revision

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

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THERMOSTATIC SHOWER RESTRICTION VALVE

Measure Description

A thermostatic valve attached to a showerhead supply for reduction of domestic hot water flow and associated energy usage. The device restricts hot water flow through the showerhead by activating the trickle or stop flow mode when water reaches a temperature set point of 95^{o}F, or slightly lower, depending on manufacturer.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

ΔkWh = units × (Deemed Annual Electric Energy Savings)

Peak Coincident Demand Savings

ΔkW = N/A

Annual Gas Energy Savings

Δtherms = units × (Deemed Annual Gas Energy Savings)

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value		Notes		
therm savings	as described in appending table		deemed annual gas energy savings for natural gas storage tank water heater		
flow rate	**1.5 gpm**	**1.75 gpm**	**2.0 gpm**	**2.25 gpm**	**2.5 gpm**
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 average	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

Variable	Value		Notes		
kWh savings	as described in appending table		deemed annual electric energy savings for electric resistance storage tank water heater		
flow rate	**1.5 gpm**	**1.75 gpm**	**2.0 gpm**	**2.25 gpm**	**2.5 gpm**
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 average	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
k_{wh} savings	deemed	Look up based on location and water usage rate (table above)
Therm savings	deemed	Look up based on location and water usage rate (table above)
GPM_{ee}		Gallons per minute for energy efficient measure, from application
$GPM_{baseline}$ (NYC)	2.0[28]	Gallons per minute for baseline in New York City, per 2012 update to NYC Plumbing Code (table 604.4)
$GPM_{baseline}$ (NYS)	2.5[1]	Gallons per minute for baseline for all other New York State areas, per NYS Energy Conservation Law, subsection 15-0314
$Flow_r$	0.75	Restricted flow rate in %
Behavioral Waste Time	1.67	Average value calculated from total water waste percentage of 30%, from abstract of reference listed below. (1 min., 40 secs.)
Showers/day	2	
$EF_{electric}$	0.97	Electric water heater efficiency, per Energy Conservation Construction Code of NYS
EF_{gas}	0.67	Natural gas water heater efficiency, per Energy Conservation Code of NYS
T_{shower}	105	The typical water temperature leaving the shower in ^oF
T_{main}		Average inlet water temperature (see appending table)

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

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

City	Annual average outdoor temperature (°F)	T_{main} (°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

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 10
Source: UPC

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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

Record of Revision Number	Issue Date
6-14-2	6/19/2014

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SHOWERHEAD – LOW FLOW

Measure Description

A low flow showerhead is a water saving showerhead rated at 2.5 gallons per minute (gpm) - the federal statutory standard for showerheads – or less. It reduces the amount of water flowing through the showerhead, compared with a standard showerhead, while maintaining similar water pressure.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times [(H_2O_{savings} \times (T_{shower} - T_{wh}) \times \left(\frac{8.33}{3{,}412}\right)] / EF_{electric}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times [(H_2O_{savings} \times (T_{shower} - T_{wh}) \times \left(\frac{8.33}{100{,}000}\right)] / EF_{gas}$$

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

$$H_2O_{savings} = [(GPM_{baseline} - GPM_{ee}) \times Flow_r \times (minutes/shower) \times (showers/day) \times 365$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
EF	= Energy factor
$H_2O_{savings}$	= Water savings
GPM	= Gallons per minute
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
$Flow_r$	= Flow rate restricted
T	= Temperature
8.33	= Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
365	= Days in one year
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU‟s
3,412	= Conversion factor, one kW equals 3,412.14 BTU/h

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		Gallons per minute for energy efficient measure. Program tracking data on rebated showerhead flow rate
$GPM_{baseline}$	3.25	Gallons per minute, baseline from LBNL study
F_r	0.75	Flow restriction factor of shower head. Used in LBNL study to adjust for occupant reduction in full flow rate
minutes/shower	8	Assumed duration of shower from LBNL study
showers/day	2	Assumed number of showers per day
T_{shower}	105	The typical water temperature leaving the shower in ^oF
T_{main}		Average inlet water temperature (see appending table)
$EF_{electric}$	0.97	Standard assumption for electric water heater efficiency
EF_{gas}	0.67	Standard assumption for gas water heater efficiency

Inlet water temperature from main, by location is shown below.

City	Annual average outdoor temperature (°F)	T main (°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

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

AIR CONDITIONER - CENTRAL (CAC)

Measure Description

A central air conditioner model consists of one or more factory-made assemblies which normally include an evaporator or cooling coil(s), compressor(s), and condenser(s). Central air conditioners provide the function of air-cooling, and may include the functions of air-circulation, air-cleaning, dehumidifying or humidifying.[29]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$\Delta therms$ = N/A

where:

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

[29] Energy Star® Program Requirements, Product Specification for Air Source Heat Pump and Central Air Conditioner Equipment, Eligibility Criteria Version 4.1

12 = kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application, default to average system size from applications if unknown
$EER_{baseline}$	11.09	Normal replacement
	9.20	Early replacement
EER_{ee}		Lookup from table below, based on unit SEER
$SEER_{baseline}$	13.00	Normal replacement
	10.00	Early replacement
$SEER_{ee}$		From application
$EFLH_{cooling}$		Lookup by vintage and city. Variability exceeds 10% across upstate (Albany, Binghamton, Buffalo, Massena and Syracuse) and NGRID (Albany, Massena and Syracuse) cities. City specific lookup must be used.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The SEER is an estimate of the average efficiency of the air conditioner over the cooling season, based on an average U.S. city. Programs should use the manufacturers" rated SEER until data can be developed that is more appropriate for NY climates.

The EER is the ARI rated full-load efficiency of the unit, which is used to estimate the unit efficiency under peak conditions.

The baseline efficiency for new construction and replace on failure is SEER 13. Baseline for early replacement is SEER 10. Early replacement units are assumed to be no more than 10 years old, with no less than 5 years of remaining life. According to the 2004-5 DEER update study, equipment of this vintage is generally SEER 10.

System Type	Baseline or Measure Assumption	Seasonal Efficiency (SEER)	Peak Efficiency (EER)[30]
Central Air conditioner	Early replacement baseline	SEER 10	9.20
	Replace on failure baseline	SEER 13	11.09
	Measure	SEER 14	11.99
		SEER 14.5	12.00[31]

[30] Peak EER by SEER Class taken from 2004-2005 DEER Update Study, with exceptions noted below.
[31] Compliant with Energy Star specifications.

System Type	Baseline or Measure Assumption	Seasonal Efficiency (SEER)	Peak Efficiency (EER)[30]
		SEER 15	12.72
		SEER 16	13.00[32]
		SEER 17	13.00[33]
Central Heat Pump	Early replacement baseline	SEER 10	9.00
	Replace on failure baseline	SEER 13	11.07
	Measure	SEER 14	11.72
		SEER 14.5	12.00[34]
		SEER 15	12.50[35]
		SEER 16	12.50[36]
		SEER 17	12.52
		SEER 18	12.80

Compliance Efficiency from which Incentives are Calculated

Central air conditioning systems with rated efficiency of 14 SEER or higher in single-family and multi-family residential applications. This section also covers cooling season impacts of central air source heat pumps.

Operating Hours

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

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Minor heating interactions are expected with efficient furnace fans utilized in most high efficiency air conditioners. These have not been quantified at this time.

Ancillary Electric Savings Impacts

References

1. Unit seasonal and peak efficiency data taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at

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32 Set to 13.0 in compliance with CEE Tier 3 Standard for SEER 16 and higher split system air conditioners
33 Ibid.
34 Compliant with Energy Star specifications
35 Set to 12.5 in compliance with CEE Tier 2 Standard on SEER 15 and higher heat pumps.
36 Ibid.

www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf
2. Typical values for coincidence factors (CF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA August, 1993.
3. SEER rated in accordance with AHRI Standard 210/240-2008. Available from the Air Conditioning Heating and Refrigeration Institute. See www.ahrinet.org

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AIR CONDITIONER - ROOM (RAC)

Measure Description

A consumer product, other than a "packaged terminal air conditioner," which is powered by a single phase electric current and is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space. It includes a prime source of refrigeration and may include a means for ventilation and heating.[37]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
units = Number of measures installed under the program
tons/unit = Tons of air conditioning per unit, based on nameplate data
EFLH = Equivalent full-load hours
EER = Energy efficiency ratio under peak conditions
CF = Coincidence factor
$_{ee}$ = Energy efficient condition or measure
$_{baseline}$ = Baseline condition or measure
12 = kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
$EER_{baseline}$		Lookup from table
EER_{ee}		From application
$\overline{EER}_{ee}$	EER_{ee}	
$EFLH_{cooling}$		Cooling equivalent full-load hours based on region see Operating Hours below.

[37] Energy Star® Program Requirements, Product Specification for Room Air Conditioners, Eligibility Criteria Version 3.1

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Baseline efficiency assumptions for normal replacement are shown below.

Room Air Conditioners with Louvered Sides

Product Class (BTU/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
< 6,000	9.7	9.7
6,000 - 8,000	9.7	9.7
8,000 – 13,999	9.8	9.8
14,000 – 19,999	9.7	9.7
≥ 20,000	8.5	8.5

Room Air Conditioners without Louvered Sides

Product Class (BTU/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
< 8,000	9.0	9.0
8,000 – 19,999	8.5	8.5
≥ 20,000	8.5	8.5

Room Air Conditioners - Casement Only

Product Class (BTU/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
All sizes	8.7	8.7

Room Air Conditioners - Casement – slider

Product Class (BTU/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
All sizes	9.5	9.5

Room Air Conditioner Heat Pumps with Louvered Sides

Product Class (BTU/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
< 20,000	9.0	9.0
≥ 20,000	8.5	8.5

Room Air Conditioner Heat Pumps without Louvered Sides

Product Class (BTU/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
< 14,000	8.5	8.5
≥ 14,000	8.0	8.0

Compliance Efficiency from which Incentives are Calculated

Room Air Conditioners with Louvered Sides

Product Class (BTU/hr)	Energy Star		CEE Tier 1		CEE Tier 2	
	$\overline{EER}$	EER_{pk}	$\overline{EER}$	EER_{pk}	$\overline{EER}$	EER_{pk}
< 6,000	10.7	10.7	11.2	11.2	11.6	11.6
6,000 - 8,000	10.7	10.7	11.2	11.2	11.6	11.6
8,000 – 13,999	10.8	10.8	11.3	11.3	11.8	11.8
14,000 – 19,999	10.7	10.7	11.2	11.2	11.6	11.6
≥ 20,000	9.4	9.4	9.8	9.8	10.2	10.2

Room Air Conditioners without Louvered Sides

Product Class (BTU/hr)	Energy Star Seasonal average efficiency ($\overline{EER}$)	Energy Star Efficiency under Peak Conditions (EER_{pk})
< 8,000	9.9	9.9
8,000 – 19,999	9.4	9.4
≥ 20,000	9.4	9.4

Room Air Conditioners - Casement only

Product Class (BTU/hr)	Energy Star Seasonal average efficiency ($\overline{EER}$)	Energy Star Efficiency under Peak Conditions (EER_{pk})
All sizes	9.6	9.6

Room Air Conditioners - Casement – slider

Product Class (BTU/hr)	Energy Star Seasonal average efficiency ($\overline{EER}$)	Energy Star Efficiency under Peak Conditions (EER_{pk})
All sizes	10.5	10.5

Room Air Conditioner Heat Pumps with Louvered Sides

Product Class (BTU/hr)	Energy Star Seasonal average efficiency ($\overline{EER}$)	Energy Star Efficiency under Peak Conditions (EER_{pk})
< 20,000	9.9	9.9
≥ 20,000	9.4	9.4

Room Air Conditioner Heat Pumps without Louvered Sides

Product Class (BTU/hr)	Energy Star Seasonal average efficiency ($\overline{EER}$)	Energy Star Efficiency under Peak Conditions (EER_{pk})
< 14,000	9.4	9.4
≥ 14,000	8.8	8.8

Operating Hours

Residential room air conditioner cooling equivalent full load hours based on region.

City	$EFLH_{cooling}$
Albany	181
Binghamton	120
Buffalo	151
Massena	143
NYC	382
Poughkeepsie	208
Syracuse	186

Effective Useful Life (EUL)

Years: 9
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. EFLH taken from Coincidence Factor Study Residential Room Air Conditioners, conducted by RLW Analytics, 2008.

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AIR CONDITIONER AND HEAT PUMP - REFRIGERANT CHARGE CORRECTION

Measure Description

Correcting refrigerant charge on air conditioners and heat pumps in single-family and multi-family residential applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER_{pk,uncorr}} - \frac{12}{EER_{corr}} \right) \times CF$$

Annual Gas Energy Savings

Δtherms = N/A

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
EFLH	= Equivalent full-load hours
EER	= Energy efficiency ratio under peak conditions
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
CF	= Coincidence factor
uncorr	= Uncorrected
corrected	= Corrected
pk	= Peak
12	= kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons	From application	From application or use 3 as default.
$SEER_{corr}$	From application	Unit nameplate SEER or default to 10 if unknown
EER_{corr}	From application	Unit EER or 9.2 as default
$SEER_{uncorr}$	From application	Use 0.9 adjustment factor or figure above if charge adjustment data available

Variable	Value	Notes
$EER_{pk, uncorr}$	From application	Use 0.9 adjustment factor or figure above if charge adjustment data available
$EFLH_{cooling}$		Vintage weighted average by city.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

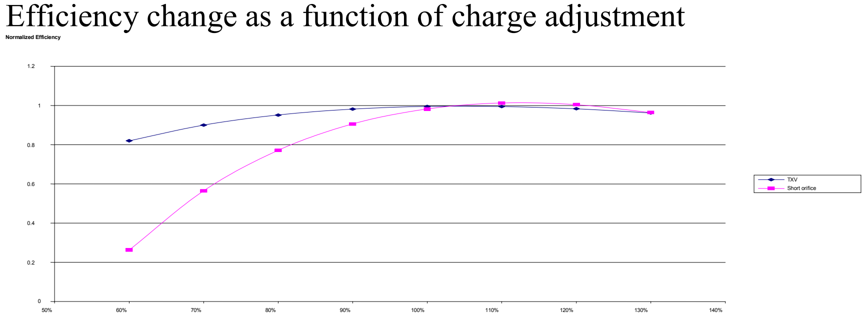
The SEER is an estimate of the average efficiency of the air conditioner over the cooling season, based on an average U.S. city. Programs should use the manufacturers" rated SEER until data can be developed that is more appropriate for NY climates. The EER is the ARI rated full-load efficiency of the unit, which is used to estimate the unit efficiency under peak conditions.

The efficiency improvement resulting from refrigerant charge adjustment depends on how far off the unit was before the adjustment was done, and whether the adjustment was done correctly. The DEER study lists two levels of charge adjustment, with a corresponding efficiency improvement: efficiency gains of 7% for refrigerant charge adjustments less than 20%, and efficiency gains of 16% for refrigerant charge adjustments greater than 20%. The magnitude of the charge adjustments expected are not known at this time, so a default value of 10% improvement in unit efficiency is recommended, the efficiency of an uncorrected unit is 10% below that of a corrected unit.

Parameter	Recommended Values
$EER_{pk, uncorr}$	$0.9 \times EER_{pk, corr}$
$SEER_{uncorr}$	$0.9 \times SEER_{corr}$

If the actual charge adjustment is recorded by the program, the efficiency adjustment factor as a function of charge adjustment is taken from the Figure below[38]. Note the efficiency change depends on the type of expansion valve. Use the curve labeled TXV for units with thermal expansion valves; otherwise use the curve labeled short orifice.

Efficiency change as a function of charge adjustment



Use uncorrected efficiency adjustment factor listed above if charge adjustment is not known, or

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

base on actual charge adjustment and figure above.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

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

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Typical efficiency change with charge adjustment taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at
2. www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf
3. Efficiency change as a function of charge adjustment curve taken from Small HVAC System Design Guide, New Buildings Institute, White Salmon, WA for the California Energy Commission.

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AIR CONDITIONER AND HEAT PUMP - RIGHT-SIZING

Measure Description

This section covers right sizing of residential central air conditioners and heat pumps. Right-sizing is a set of activities used to estimate building peak cooling load and correct system over-sizing when replacing air conditioners or heat pumps in single-family and multi-family residential applications. Equation below estimates savings from correcting over-sizing only; efficiency improvements from unit replacement are covered under the central air conditioner section.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{SEER}\right) \times EFLH_{cooling} \times PSF_{consumption}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER}\right) \times PSF_{consumption} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
EFLH	= Equivalent full-load hours
EER	= Energy efficiency ratio under peak conditions
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
CF	= Coincidence factor
PSF	= Proper sizing factor
$_{cooling}$	= Cooling
$_{consumption}$	= Consumption
12	= kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
EER	11.09	Normal replacement
SEER	13	Normal replacement
$EFLH_{cooling}$		Lookup by vintage and city.
PSF_d	0.10	Proctor, 2009
PSF_c	0.03	Proctor, 2009

Proper Sizing factor (PSF)

PSF is used to estimate the energy and demand savings from right-sizing. This factor accounts for energy savings from improved part-load performance due to reductions in unit on/off cycling; and demand savings from a lower unit connected load.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The SEER is an estimate of the average efficiency of the air conditioner over the cooling season, based on an average U.S. city. Programs should use the manufacturers" rated SEER until data can be developed that is more appropriate for NY climates.

The EER is the Air-Conditioning & Refrigeration Institute (ARI), rated full-load efficiency of the unit, which is used to estimate the unit efficiency under peak conditions.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

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

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Proper sizing factors are taken from Proctor, J. AC Sizing, Electrical Peak, and Energy Savings. Proctor Engineering Group. 2009.

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

Measure Description

This section covers the electricity savings associated with electronically commutated (EC) motors used on gas furnace distribution system supply fans. Energy and demand saving are realized through reductions in fan power due to improved motor efficiency. and variable flow operation.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (\text{Deemed Annual Electric Energy Savings})$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = The number of measures installed under the program

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh	733	Deemed annual electric energy savings for ECM, PA Consulting
ΔkW	0	Peak savings during cooling mode not considered

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.0

Baseline Efficiencies from which Savings are Calculated

Baseline efficiency calculated from existing baseline furnace with split-capacitor blower motor on distribution system.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Deemed kWh savings reference *Focus on Energy Evaluation, ECM Furnace Impact Assessment Report*. Prepared by PA Consulting for the State of Wisconsin Public Service Commission of Wisconsin, January 12, 2009.

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BOILER

Measure Description

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{\bar{\eta}_{ee}}{\bar{\eta}_{baseline}} - 1\right) \times \left(\frac{EFLH_{heating}}{100}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= The number of measures installed under the program
unit	= Measure
kBTUh	= Annual gas input rating per unit in kBTU/hr
EFLH	= Equivalent full-load hours
in	= Input capacity
heating	= Heating
$\bar{\eta}$	= Average energy efficiency (0 -100%)
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
100	= Conversion factor kBTUh/therm

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{in}$/unit		From application
$\bar{\eta}_{base}$	See table below	Defined by NYS ECCC by boiler type and size
$\bar{\eta}_{ee}$		From application, in units consistent with baseline efficiency
$EFLH_{heating}$		Lookup by vintage and city. Variability exceeds 5% across upstate (Albany, Binghamton, Buffalo, Massena and Syracuse) and NGRID (Albany, Massena and Syracuse) cities. City specific lookup must be used.

The seasonal average efficiency of the boiler is the ratio of the heating output to the fuel input over a heating season. This factor accounts for combustion efficiency, standby losses, cycling losses, and other sources of inefficiency within the boiler. The AFUE is an estimate of the seasonal heating energy efficiency for boilers less than 300 kBTU/hr input capacity. The AFUE is calculated for an average US city according to a standard US DOE method and reported by the boiler manufacturer. Programs should use the manufacturers‟ rated AFUE until data can be developed that are more appropriate for NY climates.

Boilers 300 kBTU/hr and larger are rated in terms of thermal efficiency (E_t) or combustion efficiency (E_c). Boilers 300 kBTU/hr and larger should use E_t as a proxy for the seasonal average boiler efficiency E_c may be used if E_t is not available.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.0

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
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

Compliance Efficiency from which Incentives are Calculated

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

Operating Hours

Heating equivalent full-load hours ($EFLH_{heating}$) for single-family and multi-family residential buildings were calculated from DOE-2.2 simulations of prototypical buildings. See Appendix G. $EFLH_{heating}$ assume a 3-degree thermostat setback.

Effective Useful Life (EUL)

Years: 25
Source: Efficiency VT

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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

Measure Description

This section covers electronically commutated (EC) motors in hydronic distribution circulators. A circulator pump is a specific type of pump used to circulate liquids in a closed distribution system. They are commonly found circulating water in a hydronic heating or cooling system. Because they only circulate liquid within a closed circuit, they only need to overcome the friction of a piping system (as opposed to lifting a fluid from a point of lower potential energy to a point of higher potential energy).

Circulator pumps as used in hydronic systems are usually electrically powered centrifugal pumps. As used in homes, they are often small, sealed, and rated at a fraction of a horsepower, but in commercial applications they range in size up to many horsepower and the electric motor is usually separated from the pump body by some form of mechanical coupling. The sealed units used in home applications often have the motor rotor, pump impeller, and support bearings combined and sealed within the water circuit. This avoids one of the principal challenges faced by the larger, two-part pumps: maintaining a water-tight seal at the point where the pump drive shaft enters the pump body.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

ΔkW = N/A

Annual Gas Energy Savings

$\Delta therms$ = N/A

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
$\Delta therms$	= Annual gas energy savings
units	= The number of measures installed under the program
hp	= Horsepower
Eff	= Efficiency
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
0.746	= Conversion factor (kW/hp), 746 watts equals one electric horsepower
hrs	= Hours

Summary of Variables and Data Sources

Variable	Value	Notes
hp		Circulator motor horsepower, from application
$Eff_{baseline}$	50%	Efficiency of baseline motor
Eff_{ee}	80%	Efficiency of energy efficient motor
hrs	3,240	Circulator pump operating hours, National Grid estimate

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.0

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency of a standard permanent split-capacitor (PSC) motor is estimated to be 50%. The measure efficiency of a fractional horsepower EC motor is estimated to be 80%. High efficiency circulators may include better impeller design that will increase kWh savings, but may have a negative impact on gas consumption. These effects are ignored.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Annual heating hours are based on a continuously running circulator. Savings will be less if the circulator cycles on and off with a call for heat.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

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DUCT SEALING AND INSULATION

Measure Description

Sealing and insulation of the space heating and air conditioning duct distribution system in single-family and multi-family homes. This measure reduces leakage into unconditioned and outdoor space improving system efficiency. This measure is to be installed with the assistance of a duct-blaster test on the distribution system.

A duct blaster test, similar in concept to a whole-house blower door test, is turned on to pressurize the duct system to 25 Pascal‟s (a pressure which represents typical operating pressures for forced-air systems). The airflow through the duct blaster fan (which is displayed in cfm on the duct blaster‟s manometer) equals the flow escaping through leaks in the duct system. The results are reported as "cfm @ 25 Pascal‟s".

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{SEER}\right) \times EFLH_{cooling} \times \left[1 - \frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,ee}}\right]_{cooling} + \left(\frac{kBTUh_{out}}{unit}\right) \times \left(\frac{EFLH_{heating}}{HSPF}\right) \times \left[1 - \frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,ee}}\right]_{heating}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times \left(\frac{12}{EER}\right) \times \left[1 - \frac{\eta_{dist,pk,baseline}}{\eta_{dist,pk,ee}}\right] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{EFLH_{heating}}{100}\right) \times \left[1 - \frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,ee}}\right]_{heating}$$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherm	= Annual gas energy savings
units	= Number of measures installed under the program
unit	= Measure
in	= Input capacity
out	= Output capacity

dist	= Distribution
cooling	= Cooling
heating	= Heating
dist	= Distribution
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
pk	= Peak
kBTUh	= Annual gas input rating per unit in kBTU/hr
ton/unit	= The nominal rating of the cooling capacity of the air conditioner or heat pump in tons
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
EER	= Energy efficiency ratio under peak conditions
HSPF	= Heating season performance factor
$\bar{\eta}$	= Average energy efficiency (0 -100%)
η	= Energy efficiency (0 -100%)
EFLH	= Equivalent full-load hours
CF	= Coincidence factor
12	= kBTUh/ton of air conditioning capacity
100	= Conversion factor, kBTUh/therm

Summary of Variables and Data Sources

Variable	Value	Notes
AC measure		
tons		From application
SEER	10	Existing unit
	13	New construction
$\eta_{dist, baseline}$	$\bar{\eta}_{dist, baseline}$	
$\eta_{dist, ee}$	$\bar{\eta}_{dist, ee}$	
$\bar{\eta}_{dist, baseline}$	0.956	Statewide cooling average for uninsulated duct with 20% leakage. Use measured leakage if available
$\bar{\eta}_{dist, ee}$		Use statewide average; specs based on new vs. existing construction. Measured leakage OK if available. Use appropriate R-value if duct insulation is also included.
$EFLH_{cooling}$		Vintage weighted average by city.
$EER_{baseline}$	9.2	Existing unit
	11.1	new unit
Heat pump measure		
$kBTUh/unit_{out}$		The nominal output rating of the heating capacity of the heat pump from application
HSPF	6.8	Existing unit
	8.1	New unit
Furnace measure		

Variable	Value	Notes
$kBTUh_{in}$/unit		The nominal input rating of the heating capacity of the furnace from application, from nameplate rated input in kBTU/hr.
$\bar{\eta}_{\text{dist, baseline}}$	0.934	Statewide average based on uninsulated duct with 20% leakage. Measured leakage OK if available.
$\bar{\eta}_{\text{dist, ee}}$		Statewide average; specs based on new vs. existing construction. Measured leakage OK if available. Use appropriate R-value if duct insulation is also included.
$EFLH_{heating}$		Vintage weighted average by city.

The SEER is an estimate of the average efficiency of the air conditioner over the cooling season. Most air conditioning equipment installed in residences has a SEER efficiency rating, which is an estimate of the seasonal energy efficiency for an average US city. Programs should use the manufacturers‟ rated SEER until data can be developed that is more appropriate for NY climates.

The EER is the ARI rated full-load efficiency of the unit, which is used to estimate the unit efficiency under peak conditions.

The HSPF is an estimate of the seasonal heating energy efficiency for an average US city. Programs should use the manufacturers‟ rated HSPF until data can be developed that are more appropriate for NY climates. See heat pump section for more information.

The cooling and heating season average distribution efficiencies for duct systems in residential buildings across seven New York cities are summarized in Appendix H. Ducts in single-family buildings are assumed to run in an unconditioned basement. Duct systems in low-rise multi-family buildings are assumed to run in an unconditioned space above an insulated ceiling in the top floor units, and through an unconditioned plenum space in the bottom floor units. High-rise buildings generally have hydronic systems.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Duct systems are assumed to be located in an unconditioned plenum space between insulated finished ceiling and roof surface. The baseline HSPF for heat pumps should be set according to the method described in the sections on heat pump efficiency. The baseline efficiency ($\bar{\eta}_{base}$) for furnaces should be set according to the method described in the sections on furnace efficiency. Distribution system efficiency ($\bar{\eta}_{\text{dist,baseline}}$) should be set to the unsealed and uninsulated values from the duct leakage sealing section for the appropriate building type. Use measured data when available. If measured leakage not available use 20% as the default leakage rate. Uninsulated ducts are considered to be the baseline condition.

Compliance Efficiency from which Incentives are Calculated

The measure HSPF for heat pumps should be set according to the section on efficient heat pumps. The measure efficiency ($\overline{\eta}_{ee}$) for furnaces should be set according to the section on efficient furnaces. Distribution system efficiency ($\overline{\eta}_{dist,ee}$) should be based on measured duct leakage if available. If measured leakage not available, use the Air Conditioning Contractors of America (ACCA) Quality Installation (QI) Standard specifications as a default:

Construction type	Duct location	Total Leakage (%)
New	Inside thermal envelope	10%
New	Outside thermal envelope	6%
Existing	All	20% or 50% reduction (whichever is greater)

Operating Hours

Heating equivalent full-load hours calculated from building energy simulation models described in Appendix A. Nameplate capacity for heat pumps should include the full heating capacity of the heat pump system, including backup electric resistance heaters.

Effective Useful Life (EUL)

Years: 18
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. ACCA QI specs can be found in: ANSI/ACCA Standard 5 QI-2007. HVAC Quality Installation Specification. Air Conditioning Contractors of America, Arlington, VA. www.acca.org
2. An alternative source of distribution system efficiency calculation methods is included in ANSI/ASHRAE Standard 152 – 2004 Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA. www.ashrae.org
3. The US EPA estimates total duct leakage for typical residential construction at 20% of system airflow.

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1	10/15/2010

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FURNACE

Measure Description

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

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$\Delta kWh = N/A$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{AFUE_{ee}}{AFUE_{baseline}} - 1\right) \times \left(\frac{EFLH_{heating}}{100}\right)$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = The number of measures installed under the program
unit = Measure
kBTUh = Annual gas input rating per unit in kBTU/hr
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
in = Input capacity
heating = Heating
AFUE = Annual fuel utilization efficiency
EFLH = Equivalent full-load hours
100 = Conversion factor, kBTUh/therm

Summary of Variable and Data Sources

Variable	Value	Notes
$kBTUh_{in}$		The heating input capacity is the nameplate rated input in kBTU/hr, from application
$AFUE_{baseline}$	0.80	Hot water boiler
$AFUE_{baseline}$	0.75	Steam boiler
$AFUE_{baseline}$	0.78	Furnace
$AFUE_{ee}$		From application

Variable	Value	Notes
$EFLH_{heating}$		Heating equivalent full-load hours, lookup by vintage and city.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.0

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency $AFUE_{baseline}$ for new construction and replace on failure: 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 or 80% E_t
	≥ 225 kBTU/hr	80% E_t

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Heating equivalent full-load hours for single-family and multi-family residential buildings were calculated from DOE-2.2 simulations of prototypical buildings. See Appendix G. The average seasonal efficiency of the furnace 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 for an average US city calculated according to a standard US DOE method and reported by the furnace manufacturer. Programs should use the manufacturers" rated AFUE until data can be developed that are more appropriate for NY climates.

Effective Useful Life (EUL)

Years: 20
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

EC blower motors included with high efficiency gas furnaces may provide electricity savings benefits. However, studies in Wisconsin indicate that homeowners are more likely to operate their furnace fans continuously after installing a furnace with an EC motor, potentially reducing or eliminating these savings.

References

1. For more information on EC motor savings and occupant behavior see: Pigg, Scot. "Variable Speed Furnaces Come of Age", Wisconsin Perspective, November/December 2004. Energy Center of Wisconsin, Madison, WI. www.ecw.org/download.php?producturl=/prod/articles/art1_furn.pdf

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1	10/15/2010
7-13-32	7/31/2013
8-13-1	8/31/2013

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FURNACE TUNE UP

Measure Description

This section covers tune-ups of residential natural gas furnaces to improve the seasonal heating efficiency; the tune-up affects the heating performance only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$\Delta kWh = N/A$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{EFLH_{heating}}{100}\right) \times ESF$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherm	= Annual gas energy savings
units	= Number of measures installed under the program
kBTUh	= Annual gas input rating per unit in kBTU/hr
EFLH	= Equivalent full-load hours
in	= Input capacity
heating	= Heating
ESF	= Energy savings factor
100	= Conversion factor, kBTUh/therm

Summary of Variables and Data Sources

Variable	Value	Notes
kBTUh		Annual gas input rating per unit in kBTU/hr of the furnace. Input capacity is taken from the furnace nameplate.
$EFLH_{heating}$		Heating equivalent full-load hours, relative to nameplate, lookup based on vintage and location
ESF	0.05	The energy savings factor for furnace tune-ups is used to estimate the annual heating energy savings. A value of 0.05 is recommended.

Coincidence Factor (CF)

The recommended value for the coincidence factor is: N/A

Baseline Efficiencies from which Savings are Calculated

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Heating equivalent full-load hours for single-family and multi-family residential buildings were calculated from DOE-2.2 simulations of prototypical buildings. See Appendix G.

Effective Useful Life (EUL)

Years: 5
Source: Reduced from DEER value of 10 years

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Energy savings on the order of 2% - 5% were realized from a boiler tune-up program in the Pacific Northwest. See Dethman and Kunkle, Building Tune-Up and Operations Program Evaluation. Energy Trust of Oregon, 2007.

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HEAT PUMP - AIR SOURCE (ASHP)

Measure Description

An air-source unitary heat pump model consists of one or more factory-made assemblies which normally include an indoor conditioning coil(s), compressor(s), and outdoor coil(s), including means to provide a heating function. ASHPs shall provide the function of air heating with controlled temperature, and may include the functions of air-cooling, air-circulation, air-cleaning, dehumidifying or humidifying.[39] Cooling mode savings outlined in this measure follow the residential Central Air Conditioner measure.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

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

Peak Coincident Demand Electric Savings

$$\Delta kW_{heating\ mode} = N/A$$

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

Annual Gas Energy Savings

$$\Delta therms_{heating\ mode} = N/A$$

$$\Delta therms_{cooling\ mode} = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of units installed under the program

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[39] ENERGY STAR® Program Requirements Product Specification for Air Source Heat Pump and Central Air Conditioner Equipment Eligibility Criteria
Version 4.1

tons/unit = Tons of air conditioning per unit, based on nameplate data
$kBTUh_{output}$ = The nominal rating of the heating output capacity of the heat pump in kBTU/hr (including supplemental heaters)
HSPF = Heating seasonal performance factor
SEER = Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
EER = Energy efficiency ratio under peak conditions
EFLH = Equivalent full-load hours
CF = Coincidence factor
$_{out}$ = Output capacity
$_{heating}$ = Heating
$_{ee}$ = Energy efficient condition or measure
$_{cooling}$ = Cooling
$_{baseline}$ = Baseline condition or measure
12 = kBTUh/ton of air conditioning capacity

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{output}$ / unit		From application
$HSPF_{baseline}$	8.1	Normal replacement
	6.8	Early replacement
$HSPF_{ee}$		From application
$EFLH_{heating}$		Lookup by vintage and city. Variability exceeds 5% across upstate (Albany, Binghamton, Buffalo, Massena and Syracuse) and NGRID (Albany, Massena and Syracuse) cities. City specific lookup must be used.
$EFLH_{cooling}$		Lookup by vintage and city. Variability exceeds 10% across upstate (Albany, Binghamton, Buffalo, Massena and Syracuse) and NGRID (Albany, Massena and Syracuse) cities. City specific lookup must be used.
tons		From application, default to average system size from applications if unknown
$EER_{baseline}$	11.09	Normal replacement
	9.20	Early replacement
EER_{ee}		Lookup from table below, based on unit SEER
$SEER_{baseline}$	13.00	Normal replacement
	10.00	Early replacement
$SEER_{ee}$		From application

The output capacity of the heat pump is the heating capacity of the heat pump plus backup electric resistance strip heaters at design conditions, expressed in $kBTU/hr_{output}$.

The HSPF is an estimate of the seasonal heating energy efficiency for an average US city. The average COP in the equation above is equal to the HSPF/3.412. Programs should use the manufacturers" rated HSPF until data can be developed that are more appropriate for NY climates. Efficiency assumptions for heat pumps of different SEER classes are shown below.

	Cooling Seasonal Efficiency (SEER)	**Heating Seasonal Efficiency (HSPF)[40]**
Early replacement baseline	SEER 10	6.8
Replace on failure baseline	SEER 13	8.1
Measure	SEER 14	8.6
	SEER 14.5	8.5[41]
	SEER 15	8.8
	SEER 16	8.5[42]
	SEER 17	8.6
	SEER 18	9.2

Early replacement units are assumed to be no more than 15 years old, with no less than 5 years of remaining life. According to the 2004-5 DEER update study, equipment of this vintage is generally SEER 10.

Coincidence Factor (CF)

The recommended value for the coincidence factor for the heating mode is 0.0
The recommended value for the coincidence factor for the cooling mode is 0.8

Baseline Efficiencies from which Savings are Calculated

New construction and replace on failure baseline efficiency should be consistent with a SEER 13 heat pump (HSPF = 8.1). Early replacement efficiency is assumed to be consistent with a SEER 10 heat pump (HSPF = 6.8).

The SEER is an estimate of the average efficiency of the air conditioner over the cooling season, based on an average U.S. city. Programs should use the manufacturers" rated SEER until data can be developed that is more appropriate for NY climates.

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[40] Average HSPF by SEER class taken from 2004 - 2005 DEER Update Study, with exceptions noted below.
[41] Average HSPF of SEER 14.5 Energy Star qualifying units listed in ARI/CEE directory
[42] Set at CEE Tier 2 minimum.

The EER is the ARI rated full-load efficiency of the unit, which is used to estimate the unit efficiency under peak conditions.

The baseline efficiency for new construction and replace on failure is SEER 13. Baseline for early replacement is SEER 10. Early replacement units are assumed to be no more than 10 years old, with no less than 5 years of remaining life. According to the 2004-5 DEER update study, equipment of this vintage is generally SEER 10.

System Type	Baseline or Measure Assumption	Seasonal Efficiency (SEER)	Peak Efficiency (EER)[43]
Central Air conditioner	Early replacement baseline	SEER 10	9.20
	Replace on failure baseline	SEER 13	11.09
	Measure	SEER 14	11.99
		SEER 14.5	12.00[44]
		SEER 15	12.72
		SEER 16	13.00[45]
		SEER 17	13.00[46]
Central Heat Pump	Early replacement baseline	SEER 10	9.00
	Replace on failure baseline	SEER 13	11.07
	Measure	SEER 14	11.72
		SEER 14.5	12.00[47]
		SEER 15	12.50[48]
		SEER 16	12.50[49]
		SEER 17	12.52
		SEER 18	12.80

[43] Peak EER by SEER Class taken from 2004-2005 DEER Update Study, with exceptions noted below.
[44] Compliant with Energy Star specifications.
[45] Set to 13.0 in compliance with CEE Tier 3 Standard for SEER 16 and higher split system air conditioners
[46] Ibid.
[47] Compliant with Energy Star specifications
[48] Set to 12.5 in compliance with CEE Tier 2 Standard on SEER 15 and higher heat pumps.
[49] Ibid.

Compliance Efficiency from which Incentives are Calculated

Heat pump and air conditioning efficiency must be greater than or equal to SEER 14, for single-family and multi-family residential applications

Operating Hours

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

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Minor heating interactions are expected with efficient furnace fans utilized in most high efficiency air conditioners. These have not been quantified at this time.

Ancillary Electric Savings Impacts

References

1. Unit seasonal and peak efficiency data taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf
2. Typical values for rated load factor (RLF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA August, 1993.
3. Typical values for coincidence factor (CF) for cooling mode, taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA August, 1993.
4. SEER rated in accordance with AHRI Standard 210/240-2008. Available from the Air Conditioning Heating and Refrigeration Institute. See www.ahrinet.org

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HEAT PUMP - GROUND SOURCE (GSHP)

Measure Description

A high-efficiency ground source heat pump with a closed loop vertical heat exchanger field is evaluated for single-family and multi-family applications. In single-family applications, the heat pump system utilizes a water to air heat pump with a standard forced air distribution system. The single-family system is compared to a standard efficiency air conditioner with electric resistance heat or an air-source heat pump.

In Multi-family applications, the heat pump system utilizes a water to water heat pump, two pipe distribution system, fan coils located in each zone of the apartment, and a circulation pumps between the heat pump and the fan coils and between the heat pump and the ground loop. The baseline system is a packaged terminal air conditioner (PTAC) with electric resistance heat or a packaged terminal heat pump (PTHP) with an electric resistance supplemental heating system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times \left(\frac{12}{\overline{EER}_{baseline}} - \frac{12}{\overline{EER}_{ee}} \right) \times EFLH_{cooling} + \left(\frac{kBTUh_{out}}{unit} \right) \times$$

$$\left(\frac{1}{\overline{COP}_{basline}} - \frac{1}{\overline{COP}_{ee}} \right) \times \left(\frac{EFLH_{heating}}{3.412} \right)$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$\Delta therms = N/A$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta therms$ = Annual gas energy savings
units = Number of measures installed under the program
tons/unit = Tons of air conditioning per unit, based on nameplate data
$kBTUh_{out}$ = Annual gas output rating
$\overline{EER}$ = Seasonal average energy efficiency ratio over the cooling season BTU/watt-hour, (used for a particular climate/building)

ee = Energy efficient baseline or condition
baseline = Baseline condition or measure
pk = Peak
$\overline{COP}$ = Average coefficient of performance
EFLH = Equivalent full-load hours
out = Output capacity
cooling = Cooling
heating = Heating
CF = Coincidence factor
12 = kBTUh/ton of air conditioning capacity
3.412 = Conversion factor, one watt/h equals 3.412142 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{out}$	From application	Annual gas output rating
$EFLH_{cooling}$		Cooling equivalent full-load hours
$EFLH_{heating}$		Heating equivalent full hours

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

New construction and replace on failure baseline efficiency should be consistent with a SEER 13 heat pump (HSPF = 8.1). Early replacement efficiency is assumed to be consistent with a SEER 10 heat pump (HSPF = 6.8). The seasonal Baseline systems with electric resistance heat should use a COP of 1.0. Average COP = HSPF/3.412

Compliance Efficiency from which Incentives are Calculated

Ground source heat pumps are rating at full-load and standard operating conditions.

Equipment type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure
Water-Source (Cooling Mode)	<17,000 BTU/hr	All	86°F EWT	11.2 EER	ISO-13256-1
	≥17,000 BTU/hr and <65,0000	All	86°F EWT	12.0 EER	ISO-13256-1
	≥65,000 BTU/hr and <135,0000	All	86°F EWT	12.0 EER	ISO-13256-1
Groundwater-Source (Cooling Mode)	<135,000 BTU/hr	All	59°F EWT	16.2 EER	ISO-13256-1
Ground Source (Cooling Mode)	<135,000 BTU/hr	All	77°F EWT	13.4 EER	ISO-13256-1
Water-Source (Heating Mode)	<135,000 BTU/hr	-	68°F EWT	4.2 COP	ISO-13256-1

Equipment type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure
	(Cooling Capacity)				
Groundwater-Source (Heating Mode)	<135,000 BTU/hr (Cooling Capacity)	-	50°F EWT	3.6 COP	ISO-13256-1
Ground Source (Heating Mode)	<135,000 BTU/hr (Cooling Capacity)	-	32°F EWT	3.1 COP	ISO-13256-1

The efficiency specifications account for the compressor only (water to water heat pump) or the compressor and supply fans (water to air heat pump). In order to present a valid comparison to a standard HVAC system, the energy required to run all system auxiliaries (fans, building circulating pumps, and ground loop pumps) must also be included in the full-load and seasonal average efficiencies.

These full-load and average efficiencies were developed from a simulation of a low-rise apartment retrofit to a water-to-water system with zone level fan coils, seasonal change over from heating to cooling mode, and closed-loop vertical ground loop system. System design assumptions are as follows:

Equipment	Efficiency	Notes
Heat pump (cooling mode)	17 EER	44°F chilled water, 85°F ground loop temp
Heat pump (heating mode)	4.1 COP	95°F hot water, 32°F ground loop temp
Fan coil	0.067 kW/ton	0.178 W/cfm and 375 cfm/ton
Building pump	0.041 kW/ton	10°F loop design delta T
Ground loop pump	0.11 kW/ton	10°F loop design delta T; ground loop sized at 300 LF per ton

Single-family buildings should use the manufacturers" rated EER until better data can be developed to account for system auxiliary energy use. Suggested values for the water to water system used in the multi-family application are shown below.

City	Vintage	Cool avg EER	Cook pk EER	Heat avg COP	Heat pk COP
Albany	Existing	5.8	13.8	2.7	3.2
Binghamton	Existing	5.3	13.6	2.8	3.2
Buffalo	Existing	5.3	13.9	2.8	3.0
Massena	Existing	8.0	13.6	2.6	3.5
NYC	Existing	5.9	13.7	2.7	3.1
Poughkeepsie	Existing	5.9	13.8	2.7	3.2
Syracuse	Existing	4.8	13.9	2.8	3.1
Albany	New	6.8	14.1	2.8	3.2
Binghamton	New	6.1	13.9	2.9	3.2
Buffalo	New	6.2	14.1	2.8	3.1
Massena	New	9.1	14.1	2.7	3.5
NYC	New	6.8	14.0	2.8	3.2
Poughkeepsie	New	6.8	14.1	2.8	3.2
Syracuse	New	5.6	14.1	2.8	3.1
Albany	Old	4.8	13.4	2.8	3.2
Binghamton	Old	4.2	13.0	2.9	3.2
Buffalo	Old	4.4	13.5	2.8	3.1
Massena	Old	6.9	13.3	2.8	3.5
NYC	Old	4.8	13.2	2.8	3.2
Poughkeepsie	Old	4.8	13.3	2.8	3.2
Syracuse	Old	3.7	13.5	2.8	3.0

Operating Hours

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

Effective Useful Life (EUL)

Years: 20
Source: US DOE

Ancillary Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

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Record of Revision Number	Issue Date
1	10/15/2010

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

OUTDOOR RESET CONTROL, FOR HYDRONIC BOILER

Measure Description

Reset of hot water set point in single and multi-family residential buildings with zone thermostat control. The measure is assumed to be applied to existing non-condensing boiler systems.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$\Delta kWh = N/A$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{EFLH_{heating}}{100}\right) \times F_{savings}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
EFLH	= Equivalent full-load hours
in	= Input capacity
heating	= Heating
CF	= Coincidence factor
KBTUh	= Annual gas input rating per unit in kBTU/hr
$F_{savings}$	= Savings factor
100	= Conversion factor, (kBTUh/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{in}$/unit		From application. Use deemed value of 110 kBTU/hr for residential buildings, or table above for multi-family buildings if data not available. If vintage not known, use vintage weighted values.
$EFLH_{heating}$		Lookup by vintage and city. If vintage not known, use vintage weighted values.

Variable	Value	Notes
$F_{savings}$	0.05	Recommended Energy Factor for boiler reset controllers in residential applications

The input capacity (in 1,000 BTU/hr) of the boiler should be taken from the application. If the input capacity is not know, then use the following default values:

1. Single-family residential buildings, 110 kBTU/hr
2. Multi-family buildings, input capacity can be estimated from the building type (low-rise or high-rise) and the building heated floor area using the data in the table below.

City and Vintage	Boiler Size (BTU/hr-SF)	
	High-rise (more than 3 stories)	**Low-rise (3 stories or less)**
Albany old vintage	20.2	26.0
Albany average vintage	15.4	17.0
Albany new vintage	9.9	10.0
Buffalo old vintage	18.0	23.5
Buffalo average vintage	13.8	14.9
Buffalo new vintage	8.8	9.1
Massena old vintage	22.7	28.8
Massena average vintage	17.7	18.8
Massena new vintage	11.3	11.2
NYC old vintage	13.7	19.2
NYC average vintage	10.6	11.8
NYC new vintage	6.8	7.6
Syracuse old vintage	18.6	24.6
Syracuse average vintage	14.3	15.8
Syracuse new vintage	9.1	9.5
Binghamton old vintage	19.0	24.6
Binghamton average vintage	14.6	15.9
Binghamton new vintage	9.3	9.5
Poughkeepsie old vintage	17.1	22.6
Poughkeepsie average vintage	13.2	14.4
Poughkeepsie new vintage	8.4	8.8

Coincidence Factor (CF)

The recommended value for the coincidence factor is: N/A

Baseline Efficiencies from which Savings are Calculated

Constant hot water set point temperature of 180F^o.

Compliance Efficiency from which Incentives are Calculated

Reset hot water temperature to 160F^o.
Energy Factor ($F_{savings}$) of 0.05 shall be used.

Operating Hours

Heating equivalent full-load hours for residential buildings were calculated from DOE-2.2 simulations of prototypical single-family buildings. See Appendix G.

Effective Useful Life (EUL)

Years: 15
Source: ACEEE

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

Lower set point temperature may cause hot water circulator to run longer cycles. Minor impact not accounted for in this procedure.

References

1. Energy savings factor for residential applications taken from an article published by the Energy Solutions Center, a consortium of natural gas utilities, equipment manufacturers and vendors. www.energysolutionscenter.org/BoilerBurner/Eff_Improve/Efficiency/Boiler_Reset_Control.asp

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SUB-METERING

Sub-metering of apartments in multi-family buildings, where tenants pay for their own electricity consumption according to their metered usage.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$kWh = units \times kWh/SF \times SF \times ESF$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
kWh/SF	= Annual electricity consumption per SF of conditioned floor area
SF	= Conditioned floor area per apartment subject to sub-metering
ESF	= Energy savings factor from sub-metering

Summary of Variables and Data Sources

Variable	Value	Notes
ESF	0.08	Default value, annual energy consumption per square foot of conditioned floor area should come from utility data specific to the multi-family housing stock in their service territory.

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A

Baseline Efficiencies from which Savings are Calculated

There is a significant research literature substantiating the belief that sub-metering of master-metered multi-family buildings can result in significant energy savings (see Munley et al, 1990 and Hackett & Lutzenheiser, 1991). However, rigorous estimates of the percentage of savings to be expected are scarce. A rigorous study of water sub-metering commissioned by the EPA (Aquacraft 2004) found savings of approximately 15%. While water is not electricity, arguably the same behavioral impulses can be expected to be at work. Recent NYSERDA program submittals suggested an 8% savings in total energy consumption. 8% seems to be a reasonable, albeit relatively conservative, default assumption. However, given the scarcity of recent, reliable studies, it is particularly important that savings claims from sub-metering be rigorously evaluated through ex-post studies.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years:
Source:

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Electricity Demand in Multi-Family, Renter-Occupied Residences." Munley, Vincent G.; Taylor, Larry W; Formby, John P. *Southern Economic Journal.* July 1990, pp. 178-194.
2. Social Structures and Economic Conduct: Interpreting Variations in Household Energy Consumption." Hackett, Bruce, and Loren Lutzenheiser. *Sociological Forum,* Vol. 6, No.3 (September 1991) pp. 449-470.
3. National Multiple Family Sub-metering and Allocation Billing Program Study. Prepared by Aquacraft for the UP EPA. August 2004.

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THERMOSTAT – PROGRAMMABLE SETBACK

Measure Description

Programmable setback thermostats applied to single-family and multi-family residential air conditioners, heat pumps, boilers, furnaces and electric resistance baseboard heating systems.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times \left[\left(\frac{12}{SEER}\right) \times EFLH_{cooling} \times F_{cooling} + \left(\frac{kBTUh_{out}}{unit}\right) \times \left(\frac{EFLH_{heating}}{HSPF}\right) \times F_{heating} \right]$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{EFLH_{heating}}{100}\right) \times F_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas 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
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)seasonal average energy efficiency ratio (BTU/watt-hour)
12	= kBTUh/ton of air conditioning capacity
100	= Conversion factor, kBTUh/therm
$F_{heating}$	= Energy factor for heating
$F_{cooling}$	= Energy factor for cooling
$kBTUh_{out}$	= Annual gas output rating
$kBTUh_{in}$	= Annual gas input rating
HSPF	= Heating seasonal performance factor
EFLH	= Equivalent full-load hours
heating	= Heating
cooling	= Cooling

Summary of Variables & Data Sources

Variable	Value	Notes
tons		From application or use 3 as default. Use 0 if no central cooling
$SEER_{baseline}$	10	
$EFLH_{cooling}$		Vintage weighted average by city.
$F_{cooling}$	0.09	Energy factor for cooling
$EFLH_{heating}$		Vintage weighted average by city.
$F_{heating}$	0.068	Energy factor for heating
If heat pump:		
$kBTUh/unit_{out}$		From application or use 70 kBTU/hr as default
$HSPF_{baseline}$	6.8	Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt/hr)
if furnace		
$kBTUh_{in}/unit$		From application or use 90 kBTU/hr as a default. Use wt average of furnace and boiler if system type unknown.
if boiler		
$kBTUh_{in}/unit$		From application or use 110 kBTU/hr as default. Use wt average of furnace and boiler if system type unknown.
If resistance heater		
$kBTUh_{in}/unit$		From application or use 12 kBTU/hr (3.5 kW) as default
$HSPF_{baseline}$	3.412	Equivalent to COP = 1

The nominal rating of the cooling capacity of the air conditioner or heat pump should set equal to the rated capacity of all cooling equipment controlled by a setback thermostat in the home. The energy savings should be calculated per residence rather than per thermostat.

The nominal rating of the heating capacity of the heat pump should set equal to the rated capacity of all heating equipment controlled by a setback thermostat in the home. The energy savings should be calculated per residence rather than per thermostat.

Coincidence Factor (CF)

The recommended value for the coincidence factor is: N/A

Operating Hours

Nameplate capacity for heat pumps should include the full heating capacity of the heat pump system, including backup electric resistance heaters. Cooling and heating EFLH data by location, building type and vintage are tabulated in Appendix G.

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for air conditioners and heat pumps should be set according to the sections on air conditioner and heat pump efficiency above. Electric resistance heating systems should use an HSPF = 3.412, which is equivalent to a coefficient of performance of 1.0.

Studies of residential heating thermostat set point behavior indicate some amount of manual setback adjustment in homes without programmable thermostats. This behavior is accounted for in the prototypical building simulation model used to calculate heating equivalent full-load hours, as described in Appendix A. An assumption of 3°F of night time setback behavior is embedded in the models.

Compliance Efficiency from which Incentives are Calculated

The energy savings factor for heating ($F_{heating}$) is the ratio of the energy savings resulting from installation of a programmable setback thermostat to the annual heating energy. The heating energy savings factor assumption is taken from a study of programmable thermostat savings in Massachusetts conducted by RLW Analytics. The study estimated an energy savings of 6.8% of the annual heating energy consumption for programmable setback thermostats in residential applications.

The cooling energy savings factor ($F_{cooling}$) is the ratio of the energy savings resulting from installation of a programmable setback thermostat to the annual cooling energy. The cooling energy savings factor assumption is taken from the Energy Star website. The Energy Star calculator estimates an energy savings of 3% of the annual cooling energy consumption per degree of setback for programmable setback thermostats in residential applications. Assuming an average of 3 degrees of setback, the recommended value for the cooling energy savings factor is 9%.

Operating Hours

Cooling and heating equivalent full-load hours calculated from building energy simulation models are described in Appendix A and summarized in Appendix G.

Effective Useful Life (EUL)

Years: 11
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. For examples of studies on residential thermostat set point behavior, see the literature review conducted for the California Energy Commission project "Residential Thermostats: Comfort Controls in California Homes," CEC-500-03-026, available at http://comfortcontrols.lbl.gov/pdf/tstats-lit-review.pdf.
2. Baseline thermostat setback assumptions taken from: Conner, C.C. and Lucas, R.L. 1990. Thermostat Related Behavior and Internal Temperatures Based on Measured Data in Residences. PNL-7465, Pacific Northwest Laboratory. Richland, WA.
3. The RLW study on thermostat energy savings can be found at www.cee1.org/eval/db_pdf/933.pdf
4. Programmable thermostat savings for the cooling season taken from the Energy Star website: www.energystar.gov

5. Electric resistance systems generally require line voltage thermostats capable of controlling the rated current of the baseboard unit. Programmable line voltage thermostats are not common, but are available. Thermostats controlling heat pumps should have a heat pump recovery mode to minimize operation of electric resistance heaters during the temperature recovery period.

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LIGHTING

COMPACT FLUORESCENT LAMP (CFL), AND OTHER LIGHTING TECHNOLOGIES

Measure Description

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.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = (units \times leakage) \times \Delta W/1{,}000 \times hrs_{day} \times 365 \times (1 + HVAC_c)$$

Peak Coincident Demand Savings

$$\Delta kW = (units \times leakage) \times \Delta W \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = (units \times leakage) \times (\Delta kWh \times 3.412) \times HVAC_g$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
1,000	= Conversion factor, one kW equals 1,000 watts
leakage	= Estimate of percent of units not installed in service territory
Δ	= Change, difference, or savings
W	= Watts
CF	= Coincidence factor
hrs	= Hours
3.412	= Conversion factor, one watt/h equals 3.412142 BTU
365	= Days in one year
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption

Summary of Variables and Data Sources

Variable	Value	Notes
units		From application, invoices or other documentation. Equal to number of lamps

Variable	Value	Notes
		installed and operating.
watts		CFL watts from application
ΔW = Δwatts	2.53 × CFL watts	For incandescent lamp replacement
ΔW = Δwatts	1.55 × CFL watts	For halogen lamp replacement
hrs_{day}	3.2 (CFL) 2.5 (CFL fixture)	Operating hours
365		Days in one year
Coincidence factor	0.08	Use average summer value
$HVAC_c$		HVAC interaction factor for annual electric energy consumption. Vintage and HVAC type weighted average by city (see Appendix D)
$HVAC_d$		HVAC interaction factor at utility summer peak hour. Vintage and HVAC type weighted average by city (see Appendix D)
$HVAC_g$		HVAC interaction factor for annual natural gas consumption. Vintage and HVAC type weighted average by city (see Appendix D)

1) **units** - The units term is equal to the number of lamps that are in service. This number must include leakage outside of the service territory and lamps purchased but placed in storage. Leakage occurs primarily in upstream programs, where the PA does not have control over who purchases the lamps. Some of the purchased lamps may be installed outside of the service territory. Also, some of the lamps may be placed into storage and not installed in a socket.

2**) Δ watts** (delta watts) – The difference between the lamp that is installed or would have been installed, and the higher efficiency CFL. Because the lamps 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 lamp (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 purchased is the equivalent of the lamp being replaced in terms of light output equivalency. The method is to assume that the baseline is either an incandescent lamp or a halogen lamp as appropriate.

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

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

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

Δ Watts = 1.55 × CFL wattage. Based on a halogen lamp to CFL wattage ratio or 2.55 to 1.

3) Hours of lamp use per day

Screw in CFL
Hours = 3.2 hours per day - The 3.2 hours of use per day is a value derived from an extended (nine month – May through February) logger study conducted during 2003 in Massachusetts, Rhode Island, and Vermont.[50] The Connecticut 2008 Program Savings Documentation uses 2.6 hours per day, based on a 2003 Connecticut-based study. A study of the 2005-2006 residential lighting program for Efficiency Maine reports daily hours of use at 4.8 hours from the markdown program component and 3.2 from the coupon program component.[51] This value represents a trade-off among factors that may affect the extent to which any out-of New York State value is applicable to NY. These include such factors as differences between the study area and NY, related to maturity of the CFL markets, program comparability, consumer knowledge of CFLs, and mix of locations within the house (which affects average hours of use). On balance, in considering the data and reports reviewed to date, 3.2 appears to be the most reasonable prior to New York-specific impact studies. This value is appropriate for interior applications only.

CFL Fixtures
Hours = 2.5 Hours per day - The 2.5 hours of use per day is a value derived from an extended (nine month – May through February) logger study conducted during 2003 in Massachusetts, Rhode Island, and Vermont.[52] The Connecticut 2008 Program Savings Documentation uses 2.6 hours per day, based on a 2003 Connecticut-based study. A study of the 2005-2006 residential lighting program for Efficiency Maine reports daily hours of use at 2.4 for interior fixtures.[53] The proposed value represents a trade-off among factors that may affect the extent to which any value from outside of New York State is applicable to NY. These include such factors as differences between the study area and NY related to maturity of the CFL markets, program comparability, consumer knowledge of CFLs, and mix of locations within the house (which affects average hours of use). On balance, in considering the data and reports reviewed to date, 2.5 appears to be the most reasonable prior to New York specific impact studies.

4) Days per year the lamp is on - Without any indication to the contrary, it is assumed that the lamp is used 365 days per year.

5) In-service rate - The equations are used to estimate savings per lamp, and must be multiplied by the number of lamps installed and operating. For some programs, such as upstream programs, an adjustment to the unit count must be made for lamps that may have been placed in inventory

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[50] "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1.

[51] Process and Impact Evaluation of the Efficiency Maine Lighting Program, RLW Analytics, Inc, and Nexus Market Research Inc., April 10, 2007, Table 1-2, p. 12.

[52] "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1.

[53] Process and Impact Evaluation of the Efficiency Maine Lighting Program, RLW Analytics, Inc, and Nexus Market Research Inc., April 10, 2007, Table 1-2, p. 12.

and not sold, sold to customers living outside New York State, or placed into storage and not used.

Coincidence Factor (CF)

The coincidence factors were derived from an examination of studies throughout New England that calculated coincident factors based on the definition of system peak period at the time, as specified by the New England Power Pool and later, ISO-New England.

Lighting Summer On-Peak Hours (1PM-5PM)	Coincidence Factor
June	0.07
July	0.09
August	0.09
Average Summer	0.08

Lighting Winter On-Peak Hours (5pm – 7pm)	Coincidence Factor
December	0.28
January	0.32
Average Winter	0.30

Baseline Efficiencies from which Savings are Calculated

Watts baseline 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 that 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.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

CFL, single-family, 3.2 hrs/day
CFL-fixture, single-family, 2.5 hrs/day

Effective Useful Life (EUL)

<table>
<tr><th colspan="2">Measure</th><th>Sector</th><th>Years</th><th>Source</th></tr>
<tr><td colspan="2" rowspan="4">Compact Fluorescent Lamp (CFL)</td><td rowspan="3">Residential</td><td>Coupon – 5</td><td>GDS</td></tr>
<tr><td>Direct Install – 7</td><td>GDS</td></tr>
<tr><td>Markdown - 7</td><td>GDS</td></tr>
<tr><td>Multi-family Common area</td><td>9,000 hrs/ annual operating hrs</td><td>C&I Lighting Table</td></tr>
<tr><td>Light Fixture</td><td>Linear Fluorescent</td><td>Residential / Multi-family Common area</td><td>70,000 hrs / annual operating hrs, or 20 yrs (whichever is less)</td><td>DEER</td></tr>
</table>

Measure		Sector	Years	Source
	CFL	Residential / Multi-family Common area	22,000 hrs / annual operating hrs, or 20 yrs (whichever is less)	US EPA

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. This method is based on the documentation provided in the CL&P and UI Program Savings Documentation for 2008 Program Year.
2. Other similar reports under review include the Efficiency Vermont and Efficiency Maine Technical Reference User Manuals.
3. Impact evaluations of residential lighting programs in several New England states reviewed in preparing the proposed hours-of-use values and coincidence factors include:
    a. Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs, prepared for Cape Light Compact, Vermont Public Service Department, National Grid Massachusetts and Rhode Island, Western Massachusetts Electric Company, NSTAR Electric, Fitchburg G&E by Nexus Market Research Inc., and RLW Analytics Inc., Oct 1, 200;
4. "Extended residential logging results" memo to Angela Li, National Grid, by Tom Ledyard, RLW Analytics Inc., and Lynn Hoefgen, Nexus Market Research Inc., May 2, 2005;
5. Market Progress and Evaluation Report for the 2005 Massachusetts ENERGY STAR Lighting Program, prepared for Cape Light Compact, National Grid – Massachusetts, NSTAR, Western Massachusetts Electric Company by Nexus Market Research Inc, RLW Analytics, Inc., Shel Feldman Management Company, Dorothy Conant. September 29, 2006;
6. Process and Impact Evaluation of the Efficiency Maine Lighting Program, prepared for Efficiency Maine by Nexus Market Research Inc. and RLW Analytics Inc., April 10, 2007;
7. Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007.
8. CFL to incandescent lamp wattage equivalency ratios taken from the 2008 Database for Energy Efficiency Resources (DEER) update. See www.deeresources.com for more information.

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LIGHTING - CONTROL

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COMMERCIAL AND INDUSTRIAL MEASURES

AGRICULTURAL EQUIPMENT

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AGRICULTURAL EQUIPMENT – CONTROL

ENGINE BLOCK HEATER TIMER

Measure Description

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 Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times unit/application \times W_{heater}/1{,}000 \times hrs/day_{baseline} - hrs/day_{timer} \times days_{operating}$$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$\Delta therms = N/A$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δ therms = Annual gas energy savings
units = Number of measures installed under the program
timers/app = Timers installed per application
1,000 = Conversion factor, one kW equals 1,000 watts
W = Watts
heater = Heater
$hr/day_{baseline}$ = Average hours per day heater plugged in
hr/day_{timer} = Average hours per day timer turns the heater on
$days_{operating}$ = Days per year operating

Summary of Variables and Data Sources

Variable	Value	Notes
units	from application	
W_{heater}	from application	Wattage of engine block heater; is defined as the wattage of the engine block heater under control. This value is recorded by the customer on the application.
$hr/day_{baseline}$	from application	$hr/day_{baseline}$, is defined as the average number of hours the engine block heater is plugged in and was active before the installation of the timer. This value is recorded by the customer on the application.
hr/day_{timer}	2.0	Deemed value for timer operation hr/day_{timer} is defined as the

Variable	Value	Notes
		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.
$days_{operating}$	from application	$days_{operating}$ is the number of days per year the engine block heater is operating. This value is calculated from the customer reported heater use start and end date on the application.

Coincidence Factor (CF)

The recommended value for the coincidence factor is

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.

Operating Hours

Deemed value for timer operation is 2.0 hours per day

Effective Useful Life (EUL)

Years: 8
Source: Based on EUL"s of similar control technology

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

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

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APPLIANCE

REFRIGERATOR REPLACEMENT

Measure Description

Energy Star rated (or qualified) commercial, reach-in refrigerators used in commercial foodservice applications, with an integral compressor and condenser.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = \Delta kWh \times HVAC_g$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta therms$ = Annual gas energy savings
units = Number of measures installed under the program
F_{occ} = Occupant factor
F_{market} = Market factor
CF = Coincidence factor
baseline = Baseline condition or measure
consumption = Consumption
d = Demand
g = Gas
8,760 = Hours in one year
$HVAC_c$ = HVAC interaction factor for annual electric energy consumption
$HVAC_d$ = HVAC interaction factor at utility summer peak hour
$HVAC_g$ = HVAC interaction factor for annual natural gas consumption

Summary of Variables and Data Sources

Variable	Value	Notes
v		Volume from application
$kWh_{baseline}$		Annual energy consumption for the baseline appliance, calculated from volume and type using equations above

Variable	Value	Notes
kWh_{ee}		Annual energy consumption for the energy efficient appliance, calculated from volume and type using equations above
$HVAC_c$		HVAC interaction factor for annual electric energy consumption, lookup by building type with weighted average across HVAC types. Average upstate values or NYC.
$HVAC_d$		HVAC interaction factor at utility summer peak hour, lookup by building type with weighted average across HVAC types. Average upstate values or NYC.
$HVAC_g$		HVAC interaction factor for annual natural gas consumption, lookup by building type with weighted average across HVAC types. Average upstate values or NYC.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0

The ***HVAC system interaction factor*** is defined as the ratio of the cooling energy reduction per unit of lighting energy reduction. Most of the input energy for standalone refrigeration systems is converted to heat which must be removed by the HVAC system. Reductions in refrigerator heat gains due to efficient refrigerators decrease the need for space cooling and increase the need for space heating. HVAC interaction factors vary by climate, HVAC system type and building type. Recommended values for HVAC interaction factors for refrigerator energy and peak demand savings are shown in Appendix D.

Baseline Efficiencies from which Savings are Calculated

The Foodservice Technology Center has estimated the energy consumption of baseline commercial refrigerators based on data compiled by the California Energy Commission. Baseline daily kWh for solid door and glass door commercial reach-in refrigerators are calculated as shown in the Table below. Multiply by 365 to get annual kWh.

Type	Refrigerator	Freezer
Solid Door	0.10 V + 2.04	0.40 V + 1.38
Glass Door	0.12 V + 3.34	0.75 V + 4.10

V= AHAM volume

Compliance Efficiency from which Incentives are Calculated

Commercial refrigerator and freezer energy consumption. Energy Star rated refrigerators must meet the specifications in the table below for maximum daily energy consumption (kWh/day). Multiply by 365 to get annual energy consumption.

Table 1: Maximum Daily Energy Consumption (MDEC) Requirements (kWh/day) for ENERGY STAR Qualified Commercial Food-grade Refrigerators and Freezers		
Product Volume (in cubic feet)	Refrigerator	Freezer
Vertical Configuration		
Solid Door Cabinets		
0 < V < 15	≤ 0.089V + 1.411	≤ 0.250V + 1.250
15 ≤ V < 30	≤ 0.037V + 2.200	≤ 0.400V – 1.000
30 ≤ V < 50	≤ 0.056V + 1.635	≤ 0.163V + 6.125
50 ≤ V	≤ 0.060V + 1.416	≤ 0.158V + 6.333
Glass Door Cabinets		
0 < V < 15	≤ 0.118V + 1.382	≤ 0.607V + 0.893
15 ≤ V < 30	≤ 0.140V + 1.050	≤ 0.733V – 1.000
30 ≤ V < 50	≤ 0.088V + 2.625	≤ 0.250V + 13.500
50 ≤ V	≤ 0.110V + 1.500	≤ 0.450V + 3.500
Chest Configuration		
Solid or Glass Door Cabinets	≤ 0.125V + 0.475	≤ 0.270V + 0.130

Note: V = AHAM volume, as defined in Section 1, in cubic feet (ft^3).

Operating Hours

The measure is assumed to operate 24hrs/7days per week, (8,760 hours annual operating hours)

Effective Useful Life (EUL)

Years: 12
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Efficient refrigerators reject less heat into the conditioned space, which must be made up by the space heating system. Calculations must include space heating interactions with efficient refrigerators.

Ancillary Electric Savings Impacts

References

1. US EPA energy consumption for Energy Star commercial refrigerators obtained from the Energy Star website: www.energystar.gov/index.cfm?c=commer_refrig.pr_commercial_refrigerators
2. Energy consumption for baseline refrigerators taken from the life cycle cost calculators for commercial refrigerators on the Foodservice Technology Center website: www.fishnick.com/saveenergy/tools/calculators/

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APPLIANCE – CONTROL

VENDING MACHINE AND NOVELTY COOLER TIME CLOCK

Measure Description

This measure is essentially an approach for controlling the operations of novelty coolers so that they are only operating when needed. The controls are a time-control system that allows the machines to be turned on and reach desired temperatures during the hours of business operations, but turned off during other times.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times kW_{vending} \times [(0.45 \times hrs_{off} \times 91) + (0.50 \times hrs_{off} \times 274)]$$

Peak Coincident Demand savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
Units = Number of measures installed under the program
kW = Based on nameplate Volts and Amps, Phase, and Power Factor.
vending = Vending machine
0.45 = Duty cycle during winter month nights
0.50 = Duty cycle during non-winter month nights
hrs_{off} = Potential off hours per night
91 = Days in winter months
274 = Days in non-winter months.

Summary of Variables and Data Sources

Variable	Value	Notes
0.45		Duty cycle during winter month nights, based on vendor estimates
0.50		Duty cycle during non-winter month nights, based on vendor estimates

Variable	Value	Notes
hrs_{off}		Potential off hours per night. Calculated as, number of hours store closed per day minus one (controller turns unit back on one hour before store opens).

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A

Baseline Efficiencies from which Incentives are Calculated

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 5
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

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Appliance Recycling

(place-holder)

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Building Shell

Cool Roof

Measure Description

Roofing material with reduced solar absorptance. The cool roof is assumed to have a solar absorptance of 0.3 compared to a standard roof with solar absorptance of 0.8. Due to negative impacts on space heating, this measure is applicable to buildings with air conditioning and gas heat only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times k(SF_{cool\ roof}) \times \left(\frac{\Delta kWh}{kSF}\right)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times k(SF_{cool\ roof}) \times \left(\frac{\Delta kW}{kSF}\right) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times k(SF_{cool\ roof}) \times \left(\frac{\Delta therm}{kSF}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	=Annual gas energy savings
units	= Number of measures installed under the program
k	= Thermal conductivity
SF	= Square feet
$_{cool\ roof}$	= Cool roof
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
area	sq ft of roof	From application
kSF		Calculated from thousand square feet of cool roof installed over a cooled space.
ΔkW/kSF		Lookup by building type and city, see Appendix I.

Variable	Value	Notes
Building type		From application
ΔkW/kSF		Electricity demand savings per thousand square foot of cool roof
ΔkWh/kSF		Electricity consumption savings per square foot of cool roof
Δtherm/kSF		Natural gas consumption impact per thousand square foot of cool roof installed over a heated space.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Savings are Calculated

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a series of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy and demand savings for eight building types across seven different cities in NY are shown in Appendix I.

The baseline condition for roofing material is assumed to have a solar absorptance of 0.8.

Compliance Efficiency from which Incentives are Calculated

The cool roof is assumed to have a solar absorptance of 0.3

Operating Hours

The HVAC system operating hours vary by building type. See Appendix A.

Effective Useful Life (EUL):

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Reducing roofing material solar absorptance increases space-heating requirements. The therm impacts are detailed above.

Ancillary Electric Savings Impacts

References

1. Roof absorptivity assumptions taken from California Title 24 Standards for conventional and cool roofs.

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WINDOW – FILM

Measure Description

Window films with reduced solar heat gain coefficient applied to single pane clear glass in commercial buildings. Due to negative impacts on space heating, this measure is applicable to buildings with electric AC and gas heat only.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \text{Glazing area (100 SF)} \times (\Delta kWh/\ 100\ SF)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \text{Glazing area (100 SF)} \times (\Delta kW/100\ SF) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \text{Glazing area (100SF)} \times (\Delta therm/\ 100\ SF)$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
CF = Coincidence factor
Glazing area = Aperture area of windows treated by window films in 100 SF

Summary of Variables and Data Sources

Variable	Value	Notes
Area		From application
ΔkWh/100SF		Electricity consumption savings per 100 SF of glazing area , lookup by building type and city
ΔkW/100SF		Electricity demand savings per 100 SF of glazing area, lookup by building type and city
Δtherm/100SF		Gas consumption impact per 100 square foot of glazing, lookup by building type and city
Building type		From application; use cross reference table as needed
HVAC type		Weighted average for built up systems as applicable

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a series of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy and demand savings for commercial and industrial building types across seven different cities in NY are shown in Appendix F.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be single pane clear glass with a solar heat gain coefficient of 0.87 and U-value of 1.2 BTU/hr-SF-°F.

Compliance Efficiency from which Incentives are Calculated

The window film is assumed to provide a solar heat gain coefficient of 0.40 or less.

Operating Hours

The HVAC system operating hours vary by building type. See Appendix A.

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Window film properties taken from ASHRAE Handbook of Fundamentals.

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<u>WINDOW – GLAZING</u>

Measure Description

Energy Star windows with reduced thermal conductance and solar heat gain coefficient.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times Glazing\ area\ (100SF) \times (\Delta kWh/\ 100SF) \times \frac{SEER_{baseline}}{SEER_{part}} \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times Glazing\ area\ (100\ SF) \times (\Delta kW/100SF) \times \frac{EER_{baseline}}{EER_{part}} \times \left[\frac{\eta_{dist,pk,baseline}}{\eta_{dist,pk,part}}\right]_{cooling} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times Glazing\ area\ (100SF) \times (\Delta therm/\ 100SF) \times \frac{AFUE_{baseline}}{AFUE_{part}} \times \left[\frac{\bar{\eta}_{dist,baseline}}{\bar{\eta}_{dist,part}}\right]_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	=Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
EER	= Energy efficiency ratio under peak conditions
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
AFUE	= Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
baseline	= Baseline condition or measure
part	= Participant
dist	= Distribution
heating	= Heating
cooling	= Cooling
pk	= Peak
$\bar{\eta}$	= Average energy efficiency (0 -100%)
η	= Energy efficiency (0 -100%)
Glazing area	= Aperture area of glazing

Summary of Variables and Data Sources

Variable	Value	Notes
Glazing area	(100 SF)	From application
Building type		From application; use cross reference table as needed
HVAC type		Weighted average for built up systems as applicable
ΔkWh/100SF		Electricity consumption savings per 100 SF of glazing area , lookup by building type and city, use existing window type or vintage default for baseline.
ΔkW/100SF		Electricity demand savings per 100 SF of glazing area, lookup by building type and city, use existing window type or vintage default for baseline.
Δtherm/100SF		Gas consumption impact per 100 square foot of glazing, lookup by building type and city, use existing window type or vintage default for baseline.
$EER_{baseline}$	11.1	EER used in the simulations
EER_{part}		EER of cooling systems within participant population, defaults to $EER_{baseline}$ (no adjustment)
$SEER_{baseline}$	13	SEER used in the simulations
$SEER_{part}$		SEER of cooling system within participant population, defaults to $SEER_{baseline}$ (no adjustment)
$AFUE_{baseline}$	78%	AFUE used in the simulations
$AFUE_{part}$		AFUE of heating system within participant population, defaults to $AFUE_{baseline}$ (no adjustment)
$\bar{\eta}_{dist, baseline}$	0.956	Distribution system seasonal efficiency used in simulations
$\bar{\eta}_{dist, part}$		Distribution system seasonal efficiency within participant population, defaults to $\bar{\eta}_{dist, baseline}$ (no adjustment)
$\eta_{dist, pk, baseline}$	0.956	Distribution system efficiency under peak conditions used in simulation
$\eta_{dist, pk, part}$		Distribution system efficiency under peak conditions within participant population defaults to $\eta_{dist, pk, baseline}$ (no adjustment)

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

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Savings are Calculated

A variety of existing window combinations are shown in the unit savings tables, including single pane clear glass with a solar heat gain coefficient of 0.87 and U-value of 0.93 BTU/hr-SF-°F, double pane clear glass with a solar heat gain coefficient of 0.62 and U-value of 0.55 BTU/hr-SF-°F, and a minimally code compliant window with a solar heat gain coefficient of 0.34 and U-value of 0.35 BTU/hr-SF-°F. Energy savings are estimated based on the characteristics of the existing window. Single pane clear glass is the default for the old vintage, while double pane clear glass is the default for the average vintage. The minimally code compliant window as assumed to be the base case for new construction or window replacement projects.

Compliance Efficiency from which Incentives are Calculated

A typical window meeting the current Energy Star specifications is assumed to be the installed measure. The solar heat gain coefficient is assumed to be 0.34 with a U-value of 0.30 BTU/hr-SF-°F.

Operating Hours

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

Effective Useful Life (EUL)

Years: 20
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Window properties for baseline windows taken from 2009 ASHRAE Handbook of Fundamentals Chapter 15.
2. Typical values for coincidence factors (CF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol. 2. Electric Power Research Institute, Palo Alto, CA. August, 1993.

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COMPRESSED AIR

AIR COMPRESSOR

Measure Description

This section covers compressor upgrades in commercial and industrial compressed air systems.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = hp_{comp} \times (\Delta kW/hp) \times hr$$

Peak Coincident Demand Savings

$$\Delta kW = hp_{comp} \times (\Delta kW/hp) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
hp_{comp} = Air compressor horsepower
hr = Annual operating hours of air compressor
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
hp_{comp}		Compressor horsepower from application
ΔkW/hp		Lookup based on compressor size and load control strategy
hours		From application

Compressor Measure

Control type	Compressor hp	ΔkW/hp
Load/No Load	≥ 15 and < 25	0.102
Load/No Load	≥ 25 and < 75	0.102
VSD	≥ 15 and < 25	0.207
VSD	≥ 25 and < 75	0.206
Variable displacement	≥ 50 and < 75	0.116

Coincidence Factor (CF):

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Typical modulating compressor with blow down.

Compliance Efficiency from which Incentives are Calculated

Oil flooded, rotary screw compressor with Load/No Load, variable speed drive, or variable displacement capacity control and properly sized receiver. Flow controller must be used to maintain 5-10 psi pressure difference between receiver and distribution system.

Operating Hours

Varies by application.

Effective Useful Life (EUL):

Years: 15
Source: Ohio TRM

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

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AIR DRYER - REFRIGERATED

Measure Description

High efficiency air dryers utilizing a refrigeration system to condense and remove moisture from a compressed air system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = CFM_{dryer} \times (\Delta kW/CFM) \times hr$$

Peak Coincident Demand Savings

$$\Delta kW = CFM_{dryer} \times (\Delta kW/CFM) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CFM_{dryer}	= Full flow rated capacity of refrigerated air dryer (cfm)
ΔkW/cfm	= kW reduction per full flow rated cfm
Hr	= Annual operating hours of dryer
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
CFM_{dryer}		From application
ΔkW/cfm		Lookup based on dryer size From MA TRM
hours		From application
ΔkW/CFM	0.005	Dryer capacity (CFM_{dryer}) <100
	0.004	Dryer capacity (CFM_{dryer}) ≥ 100 and < 200
	0.003	Dryer capacity (CFM_{dryer}) ≥ 200 and < 300
	0.003	Dryer capacity (CFM_{dryer}) ≥ 300 and < 400
	0.003	Dryer capacity (CFM_{dryer}) ≥ 400

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Savings are Calculated

Non-cycling refrigerated air dryer.

Compliance Efficiency from which Incentives are Calculated

High efficiency refrigerated dryer.

Operating Hours

Varies by application.

Effective Useful Life (EUL):

Years: 15
Source: Ohio TRM

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit savings values taken from the Massachusetts Statewide Technical Reference Manual. Prepared by VEIC for the Mass Department of Energy Resources, 2009.

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ENGINEERED AIR NOZZLE

Measure Description

This section covers engineered compressed air nozzles. Engineered nozzles entrain building air with compressed air to provide effective air nozzle action while reducing compressed air system air flow.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = (FLOW_{baseline} - FLOW_{eng}) \times kW_{scfm} \times \%_{use} \times hr$$

Peak Coincident Demand Savings

$$\Delta kW = \Delta kWh / hr \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \Delta therm_{wh} + \Delta therm_{dryer}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$FLOW_{baseline}$	= Open nozzle flow
$FLOW_{eng}$	= Engineered nozzle flow
$kW/_{scfm}$	= Air compressor kW per cfm air delivery at 100 psi
$\%_{use}$	= Percent of compressor operating hours where nozzle is in use
hr	= Annual operating hours
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
$FLOW_{baseline}$	Lookup based on nozzle size	Nozzle size from application
$FLOW_{eng}$	Lookup based on nozzle size	Nozzle size from application
$kW/_{scfm}$	0.29	Value taken from Ohio TRM
$\%_{use}$	0.05	
hr		Annual operating hours of air compressor, from application

	Standard Nozzle (SCFM) at 100 psi	Engineered Nozzle (SCFM) at 100 psi
1/8 in. nozzle	21	6
¼ in. nozzle	58	11

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.75

Baseline Efficiencies from which Savings are Calculated

Typical modulating compressor with blow down system assumed, with baseline nozzle as defined above.

Compliance Efficiency from which Incentives are Calculated

Typical modulating compressor with blow down system assumed, with efficient nozzle as defined above.

Operating Hours

Nozzles assumed to be in use 5% of the time the compressor system is available.

Effective Useful Life (EUL):

Years: 15
Source: PA Consulting for Wisconsin PSC

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Flow data for baseline nozzles taken from Machinery‟s Handbook, 25th Edition.
2. Efficient nozzle data taken from a survey of Manufacturers' data. See the Ohio Technical Reference Manual, VEIC. 2010.

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No Air Loss Water Drain

Measure Description

This section covers a no-loss compressed air system water drain. No-loss drains allow water to drain from the compressed air system without compressed air loss.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (\Delta kW/drain) \times hrs$$

Peak Coincident Demand Energy Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
hr = Annual operating hours
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
units		Number of drains, from application
ΔkW/drain	0.3kW	National Grid recommended value
hrs		Annual operating hours of air compressor, from application

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8.

Baseline Efficiencies from which Savings are Calculated

Electronic solenoid / timed drains.

Compliance Efficiency from which Incentives are Calculated

No loss drain with a Load/No-load with appropriately sized storage, VSD or variable displacement compressor.

Operating Hours

Varies by application.

Effective Useful Life (EUL):

Years: 15
Source: Ohio TRM

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit demand savings value suggested by National Grid. This value is considered to be conservative relative to other values. For example, Xcel Energy of Colorado uses a deemed value of 0.53. See Xcel Energy Technical Reference Manual for the 2011 DSM programs, Xcel Energy, Denver CO. 2010.

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DOMESTIC HOT WATER

INDIRECT WATER HEATER

Measure Description

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.

Method for Calculating Annual Energy and Peak Coincidence Demand Savings

Annual Electric Energy Savings

$\Delta kWh = N/A$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$\Delta therms = units \times$

$$\left[\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{100{,}000} \times \left[\frac{1}{E_{c,\ baseline}} - \frac{1}{E_{c,ee}}\right] + \left(\frac{UA_{baseline}}{E_{c,baseline}} - \frac{UA_{ee}}{E_{c,ee}}\right) \times \frac{\Delta T_s}{100{,}000} \times 8760\right]$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
$\Delta therms$	= Annual gas energy savings
units	= Number of measures installed under the program
UA	= Overall heat loss coefficient (BTU/hr-°F)
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
ΔT_s	= Temperature difference between the stored hot water and the surrounding air (°F)
GPD	= Gallons per day
$\overline{\Delta T}_w$	= Average difference between the cold inlet temperature and the hot water delivery temperature (°F)
E_c	= Boiler combustion efficiency
$E_{c,\ baseline}$	= Baseline water heater efficiency

8.33 = Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
100,000 = Conversion factor, (BTU/therm), one therm equals 100,000 BTU‟s
365 = Days in one year

Summary of Variables and Data Sources

Variable	Value	Notes
$UA_{baseline}$		Overall heat loss coefficient of base tank type water heater (BTU/hr-°F). Calculate from baseline water heater $SL_{baseline}$ or lookup table based on tank volume and insulation thickness
UA_{ee}		Overall heat loss coefficient of indirect water heater storage tank (BTU/hr-°F). Calculate from equation or lookup table based on tank volume and insulation thickness
ΔT_s	$T_{set} – T_{amb}$	Temperature difference in degrees Fahrenheit, between the stored hot water and the surrounding air.
GPD		Default to 78 gallons per day for single-family residential, otherwise from application
ΔT_w	$T_{set} – T_{main}$	Temperature difference between tank set point and water main temperature
$E_{c, baseline}$	0.75 (gas)	Combustion efficiency of baseline appliance
$E_{c, ee}$		Combustion efficiency of energy efficient boiler from application
$E_{c, baseline}$	$RE_{baseline}$	(=$RE_{baseline}$ if tank type baseline; $E_{c, baseline}$ if indirect baseline)
v		Volume, from application
T_{set}	130°F	Temperature set point of water in tank
T_{amb}	67.5°F	Ambient temperature of surrounding air temperature
T_{main}		Average Temperature in supply water main based on upstate or downstate
$SL_{baseline}$		Standby heat loss, from manufacturers‟ data

The *ambient temperature difference* between the water heat set point and the ambient room temperature is used to calculate the standby losses. Water heaters are generally located in conditioned or partially conditioned spaces to avoid freezing. A room temperature of 67.5°F is the default value.

The *water temperature difference* between the water heat set point and cold water main temperature is used to calculate the hot water load. If the water heater has sufficient capacity to meet the load, hot water will be delivered at the water heater set point temperature. Water heater set point for commercial buildings is usually in the range of 150°F to 190°F. The water heater set point should be consistent with temperature assumed in the water use data.

Cold water entering temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Annual average outdoor temperature (°F)	T main (°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

The ***average daily hot water usage***, expressed in gallons per day across each commercial building type is shown in the following Table.

Building Type	GPD	Rate	Notes	Source
Assembly	150	5 per seat	water not HOT water; assume 10% hot water, 300 seats	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	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	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

Building Type	GPD	Rate	Notes	Source
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	www.p2pays.org/ref/42/41980.pdf
Hotel	9,000		3/4 of Hotel	Staff Estimate
Industrial Refrigerati on	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	www.p2pays.org/ref/42/41980.pdf
Warehouse	100		assume like Small Office	Staff Estimate

Tank overall heat loss coefficient (UA) is used to calculate standby losses. The UA is calculated from the standby loss specification, or from the tank size and insulation thickness.

$$UA = SL/70 \ (BTU/hr\text{-}^{\circ}F)$$

where:

SL = Standby heat loss (BTU/hr)

70 = Temperature difference associated with standby heat loss specification

UA values for indirect water heater tanks can be estimated from the tank physical size and insulation type and thickness.

$$UA_{baseline} = \frac{2\pi k_{side} H}{\ln(\frac{r_2}{r_1})} + \frac{\pi r_1^2 k_{bot}}{th_{bot}} + \frac{\pi r_1^2 k_{top}}{th_{top}}$$

where:

k_{side} = Thermal conductivity of tank sidewall insulation (BTU/hr-ft-°F)
k_{bot} = Thermal conductivity of tank bottom insulation (BTU/hr-ft-°F)
k_{top} = Thermal conductivity of tank top insulation (BTU/hr-ft-°F)
k_{wrap} = Thermal conductivity of tank wrap (BTU/hr-ft-°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 small indirect water heater tanks are shown below.

Volume (gal)	H (bare tank) inches	Diameter (bare tank) inches	Insulation	UA (BTU/hr-°F)
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

Larger tank UA values are shown below.

Water heater size (gal)	Height (in)	Diameter (in)	UA (BTU/hr- °F)				
				Fiberglass		Foam	
			Bare tank	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
1,000	138	48	177.9	43.5	22.1	34.6	17.6

Standby losses (SL) for large gas storage type water heaters (> 75,000 BTU/hr input capacity (Q) and storage size <4000 BTU/hr/gal):

$$SL = Q/800 + 110\sqrt{V} \text{ (BTU/hr)}$$

Standby losses for large electric storage type water heaters (>12kW and > 20 gallons):

$$SL = 20 + 35\sqrt{V} \text{ (BTU/hr)}$$

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Baseline thermal efficiency for gas water heaters is assumed to be 0.80. Baseline efficiency for existing boilers is 0.75. Note: combustion efficiency (E_c) may be substituted for thermal efficiency if thermal efficiency is not known.

Compliance Efficiency from which Incentives are Calculated

Indirect water heater must be combined with an efficient space heating boiler meeting program specifications.

Operating Hours

Water heater assumed to be available at all hours.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

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

Ancillary Electric Savings Impacts

References

1. 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
2. Water main 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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STORAGE TANK WATER HEATER

Measure Description

Natural gas fired domestic hot water appliance utilizing a storage tank, installed in whole-building applications and designed to heat and store water at a thermostatically controlled temperature.

Method for Calculating Annual Energy and Peak Coincidence Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T}}{3{,}412} \times \left\lfloor \frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}} \right\rfloor$$

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therm = units \times \frac{GPD \times 365 \times 8.33 \times \overline{\Delta T}}{100{,}000} \times \left\lfloor \frac{1}{E_{t,baseline}} - \frac{1}{E_{t,ee}} \right\rfloor$$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
UA	= Overall heat transfer coefficient (BTU/hr-°F)
baseline	= Baseline
ee	= Energy efficient
$E_{t, baseline}$	= Baseline water heater thermal efficiency
$E_{t, ee}$	= Baseline water heater thermal efficiency
ΔT	= Temperature difference between storage tank set point temperature and surrounding air ambient temperature
$\overline{\Delta T}$	= Average temperature difference between storage tank set point temperature and surrounding air ambient temperature
CF	= Coincidence factor
GPD	= Gallons per day
3,412	= Conversion factor, one kW equals 3,412.14 BTU/h
8.33	= Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor, (BTU/therm), one therm equals 100,000 BTU‟s
365	= Days in one year

Summary of Variables and Data Sources

Variable	Value	Notes
$UA_{baseline}$		Overall heat loss coefficient of base water heater (BTU/hr-°F), calculate from baseline appliance standby-loss ($SL_{baseline}$)
UA_{ee}		Overall heat loss coefficient of efficient water heater (BTU/hr-° F), calculate from energy efficient appliance standby-loss (SL_{ee})
ΔT_s	$T_{set} – T_{amb}$	Temperature difference between storage tank set point temperature and surrounding air ambient temperature (°F)
GPD		From application; defaults by building type shown in Table above.
ΔT_w	$T_{set} – T_{main}$	Temperature difference between the water inside the tank and the main (°F)
$Et_{baseline}$	1.0 (electric)	Thermal efficiency for baseline electric appliance
$Et_{baseline}$	0.75 (gas)	Thermal efficiency for baseline natural gas appliance
Et_{ee}		Thermal efficiency for energy efficient appliance, from application
Tank volume		Tank volume from application
T_{set}	140	Commercial water heater set point (°F) consistent with GPD data
T_{amb}	67.5	Ambient temperature of surrounding air (°F)
T_{main}		Average T_{main} based on upstate or downstate (°F)
Capacity (Q)		From application (natural gas only)
$SL_{baseline}$		Stand by heat loss for baseline appliance, calculate from tank volume, capacity (gas only) and fuel type

Water heating energy consumption is calculated from the daily hot water use and the difference in the water heater delivery temperature and entering cold water temperature. If the supplemental water heater has sufficient capacity to meet the load, hot water will be delivered at the water heater set point temperature. Water heater set point for commercial buildings is usually in the range of 150°F to 190°F. The water heater set point should be consistent with temperature assumed in the water use data. If the water heater does not have sufficient capacity to meet the load, the hot water delivery temperature may need to be reduced from the set point temperature.

Cold water entering temperatures vary according to climate, and are approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Annual Average outdoor temperature (°/F)	T main (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7

City	Annual Average outdoor temperature (°/F)	T main (°F)
Syracuse	48.6	54.6
Upstate Average	47.3	53.3
Long Island	56.5	62.5
NYC	56.5	55.0

The ***thermal efficiency*** is a measure of the efficiency of the instantaneous and storage water heaters excluding standby losses. Larger water heaters used in commercial applications are rated with thermal efficiency instead of energy factor.

The ***average daily hot water usage***, expressed in gallons per day across each commercial building type is shown in the following table:

Proposed Deemed Values for Gallons of Hot Water Use per Day (GPD) by Builiding 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	1152	2.4 GPD per meal	40 meals per hour, 12 hr per day	NY TRM
Grocery	200		assume 2x Big Box	Staff estimate
Hospital	12000	300 GDP 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 GDP per person	assume 500 ppl	NY TRM
Light Industrial	1250	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
Multifamily high-rise	920	46 GPD per unit	20 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/(	NY TRM
Multifamily 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	1440		assume like Secondary School	Staff estimate
Dormitory	14700		Single-person household - 500 students	Staff estimate
Heavy Industrial	1250	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	9000		3/4 of hotel	Staff estimate
Industrial Refrigeration	29		Assume like Auto Repair	Staff estimate
Motel	4500		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	1440	1.8 GPD per student	800 students; reduce days per year to reflect school calendar	NY TRM
University	3450	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

Tank overall heat loss coefficient ***(UA)*** is calculated from the standby loss specification:

$$UA = SL/70 \text{ (BTU/hr-}^{o}\text{F)}$$

where:

SL = Standby loss (BTU/hr)

70 = Temperature difference associated with standby loss specification (^{o}F)

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Baseline thermal efficiency for electric water heaters is assumed to be 1.0. Baseline thermal efficiency for gas water heaters is assumed to be 0.75.

Standby losses (SL) for large electric storage type water heaters (> 12kW and > 20 gallons):

$SL = 20 + 35\sqrt{V}$ (BTU/hr)

Standby losses (SL) for large gas storage type water heaters (> 75,000 BTU/hr input capacity (Q) and storage size <4000 BTU/hr/gal):

$SL = Q/800 + 110\sqrt{V}$ (BTU/hr)

Compliance Efficiency from which Incentives are Calculated

Program administrators should use the thermal efficiency specifications for qualifying water heaters under their respective programs.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Operating Hours

Water heater assumed to be available at all hours.

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

High-efficiency water heaters may incorporate a draft fan, which increases electricity consumption.

References

1. 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
2. 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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DOMESTIC HOT WATER (DHW) – CONTROL

FAUCET – LOW FLOW AERATOR

Measure Description

A faucet aerator is a water saving device that, by federal guidelines that went into effect in 1994, enables no more than 2.2 gallons per minute (gpm) to pass through the faucet. A low flow faucet aerator can reduce water flow to 1.5 gpm while maintaining appropriate water pressure and flow.

Method for Calculating Annual Energy and Peak Coincident Demand Savings[54]

Annual Energy Savings Method

The savings estimations were derived through the following steps:

Water Savings = ((Standard – low flow aerator GPM) × (duration/use) × (#uses/day) × (days/year))

Develop estimate of annual gallons of water saved from the measure

$$H_2O_{Sav} = (GPM_{baseline} - GPM_{ee}) \times Dur \times Use \times Days$$

where:

H_2O_{Sav} = Water savings
GPM = Gallons per minute
$_{baseline}$ = Baseline condition or measure
$_{ee}$ = Energy efficient condition or measure
Dur = Duration of water flow per usage
Use = Uses of water per day
Days = Days per year

Annual Electric Energy Savings

$$\Delta kWh = ((H2^0_{Sav} \times (T_{faucet} - T_{heater}) \times 8.33/3{,}412)) / EF_{electric}$$

where:

ΔkWh = Electric energy savings
H_2O_{Sav} = Water savings (calculated from above)
T_{faucet} = Temperature of faucet water
T_{heater} = Temperature to heater
8.33 = Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
3,412 = Conversion factor, one kW equals 3,412.14 BTU/h
$EF_{electric}$ = Energy factor for electric water heater

[54] This methodology is derived from CL&P and UI Program Savings Documentation for 2008 Program Year, pp. 157-158.

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$$\Delta therms = H20_{Sav} \times (T_{faucet} - T_{heater}) \times (8.33/100{,}000)) / EF_{gas}$$

where:

H_2O_{Sav} = Water savings (calculated from above)
T_{faucet} = Temperature of faucet water
T_{heater} = Temperature to heater
8.33 = Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
100,000 = Conversion factor (BTU/therm), one therm equals 100,000 BTU‟s
EF_{gas} = Energy factor for natural gas water heater

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}	1.5	Gallons per minute for energy efficient measure
$GPM_{baseline}$	2.2	Gallons per minute for baseline measure
Duration of use (minutes)	0.5	
Uses per day	30	
Days per year	260	Average days of operation for businesses
T_{faucet}	80	Temperature of water at faucet
T_{main}		Average T_{main} based on upstate or downstate
Water heater efficiency	0.97	Standard assumptions for electric water heater efficiency
	0.67	Standard assumptions for natural gas water heater efficiency

The table below provides the baseline (standard) and low flow aerator water flows, related input assumptions, and the resulting water savings. Assumptions regarding average duration of use and number of uses per day are also presented. This is based on the CL&P and UI savings document, which itself relied on FEMP assumptions.[55]

[55] Federal Energy Management Program “Domestic Water Conservation Technologies” at www1.eere.energy.gov/femp/pdfs/22799.pdf and other sources.

Variable	Value	Notes
Standard aerator	2.2 GPM	
Replacement low flow aerator	1.5 GPM	
Savings in GPM	0.7 GPM	
Duration of use (minutes)	0.5	
No. of uses/day	30	
Days/year	260	
Gallons of water saved/year	2,730	

Typical value for water temperature leaving the faucet is 80 °F, by location:

City	Annual average outdoor temperature (°F)	T main (°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

The recommended value for the coincidence factor is 0.8

Baseline Efficiency from Which Savings are Calculated

Compliance Efficiency from which Incentives are Calculated

Operating Hours: N/A

Effective Useful Life

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Methodology derived from CL&P and UI Program Savings Documentation for 2008 Program Year, pp. 157-158.
2. See Federal Energy Management Program "Domestic Water Conservation Technologies" for water savings data. www1.eere.energy.gov/femp/pdfs/22799.pdf
3. 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
4. Water main 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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SHOWERHEAD – LOW FLOW

Measure Description

A low flow showerhead is a water saving showerhead rated at 2.5 gallons per minute (gpm) - the federal statutory standard for showerheads – or less. It reduces the amount of water flowing through the showerhead, compared with a standard showerhead, while maintaining similar water pressure.

Method for Calculating Annual Energy and Peak Coincident Demand Savings [56]

Develop estimate of annual gallons of water saved from the measure

$$H_2O_{sav} = (GPM_{baseline} - GPM_{ee}) \times F_{restriction} \times Dur \times Use \times Days$$

where:

H_2O_{sav}	= Water savings
$GPM_{baseline}$	= Gallons per minute for baseline measure
GPM_{ee}	= Gallons per minute for low flow aerator
$F_{restriction}$	= Flow restriction
Dur	= Duration of water flow per usage (minutes)
Use	= Use of water per day
Days	= Days per year of use

Annual Electric Energy Savings

$$\Delta kWh = ((H_2O_{sav} \times (T_{faucet} - T_{heater}) \times (8.33 / 3{,}412)) / EF_{electric}$$

where:

ΔkWh	= Annual electric energy savings
$H20_{sav}$	= Water savings (calculated from above)
T_{shower}	= Temperature to shower
T_{heater}	= Temperature to heater
8.33	= Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU‟s
3,412	= Conversion factor, one kW equals 3,41214 BTU/h
$EF_{electric}$	= Energy factor for electric water heater

Peak Coincident Demand Savings

ΔkW = N/A

[56] This methodology is derived from CL&P and UI Program Savings Documentation for 2008 Program Year, pp. 155-156.

Annual Gas Energy Savings

$$\Delta therms = H_2O_{sav} \times (T_{shower} - T_{heater}) \times (8.33 / 100{,}000)) / EF_{gas}$$

where:

Δtherms	= Annual gas energy savings
H_2O_{sav}	= Water savings (calculated from above)
T_{shower}	= Temperature to shower
T_{heater}	= Temperature to heater
8.33	= Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
100,000	= Conversion factor (BTU/therm), one therm equals 100,000 BTU‟s
EF_{gas}	= Energy factor for natural gas water heater

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		Gallons per minute for energy efficient measure, from application
$GPM_{baseline}$	3.25	Gallons per minute for baseline measure
Throttle factor	0.75	Restriction factor
Min/shower	8	Minutes of use per shower event
Shower/day		Number of shower events per day, from application; varies across building types
T_{shower}	105	Temperature of water at showerhead
T_{main}		Average temperature of water in supply main, based on upstate or downstate
Water heater efficiency	0.97	Efficiency of electric water heater
	0.67	Efficiency of natural gas water heater

Recommended values are shown in the table below.

Parameter	Value	Source
$GPM_{baseline}$	3.25	LBNL study
GPM_{ee}		Program tracking data on rebated showerhead flow rate
Throttle factor	0.75	Used in LBNL study to adjust for occupant reduction in full flow rate
Minutes per shower	8	LBNL study
Showers per day		Varies by building

Typical value for water temperature leaving the shower is 105°F, by location:

City	Annual average outdoor temperature (°F)	T main (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9

City	Annual average outdoor temperature (°F)	T main (°F)
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

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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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HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

AIR CONDITIONER AND HEAT PUMP - REFRIGERANT CHARGE CORRECTION

Measure Description

Correcting refrigerant charge on air conditioners and heat pumps in small commercial applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Energy Savings

$$\Delta kWh = units \times (tons/units) \times [(12 / SEER_{uncorr}) - 12 / SEER_{corr})] \times EFLH_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times (tons/units) \times [(12 / EER_{uncorr.pk}) - (12 / EER_{corr,\ pk})] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
SEER	= Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling, in BTU/h, divided by the total electric energy input during the same period, in watt-hours
EER	= Energy efficiency ratio, measurement of cooling capacity for a unit (in BTU/hour) / electrical energy used (watts) at a specific temperature of (95^{o}F)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor
12	= kBTUh/ton of air conditioning capacity
tons/unit	= Tons of air conditioning per unit, based on nameplate data
$_{pk}$	= Peak
$_{corr}$	= Corrected
$_{uncorr}$	= Uncorrected

Summary of Variables and Data Sources

Variable	Value	Notes
$EER_{pk,\ uncorr}$	$0.9 \times EER_{pk,\ corr}$	Recommended value
$SEER_{uncorr}$	$0.9 \times SEER_{corr}$	Recommended value

Coincidence Factor (CF)

Recommended value for the coincidence factor is 0.8

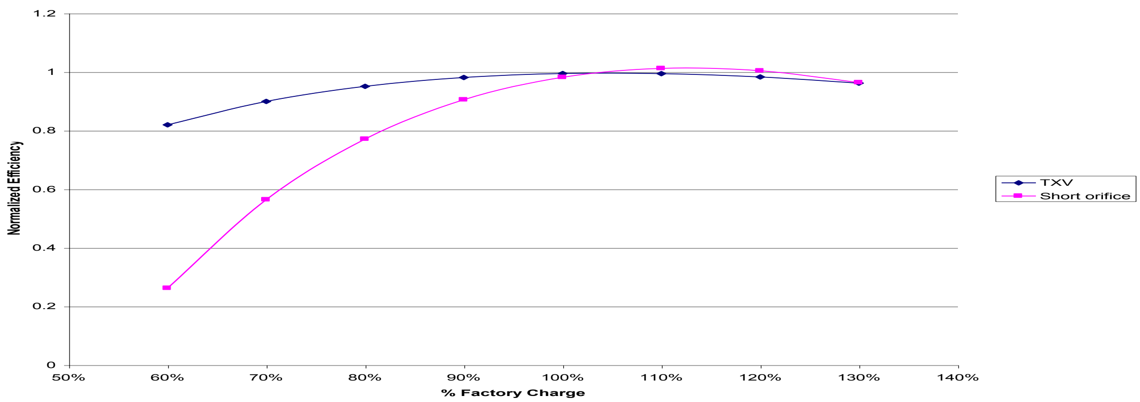
Baseline Efficiencies from which Savings are Calculated

The baseline (uncorrected) efficiency is adjusted relative to the nominal (corrected) unit efficiency based on the recorded charge adjustment and the graph above. Use a 0.9 adjustment factor if charge adjustment amount not known.

Efficiency assumptions for properly charged air conditioners and heat pumps in several size classes are shown below.

Equipment Category	Capacity Range (BTU/hr)	Baseline Efficiency	
		Average	
Unitary A/C (1) phase	<65,000 1 phase	13.0 SEER	Unitary A/C (1) phase
Unitary A/C (3) phase	<65,000 3 phase	13.0 SEER	Unitary A/C (3) phase
Unitary A/C (3) phase	65,000 - 135,000	11.2 IEER	Unitary A/C (3) phase
Unitary A/C (3) phase	135,000 - 240,000	11.0 IEER	Unitary A/C (3) phase
Unitary A/C (3) phase	240,000 - 760,000	9.9 IEER	Unitary A/C (3) phase
Unitary A/C (3) phase	>760,000	9.6 IEER	Unitary A/C (3) phase
Unitary HP (1) phase	<65,000 1 phase	13.0 IEER	Unitary HP (1) phase
Unitary HP (3) phase	<65,000 3 phase	13.0 IEER	Unitary HP (3) phase
Unitary HP (3) phase	65,000 - 135,000	11.0 IEER	Unitary HP (3) phase
Unitary HP (3) phase	135,000 - 240,000	10.5 IEER	Unitary HP (3) phase
Unitary HP (3) phase	240,000 - 760,000	9.4 IEER	Unitary HP (3) phase

Efficiency impacts are proportional to the magnitude of the charge adjustment. When data are collected in the field that records the charge adjustment amount as a percentage of the factory charge, use the graph below to determine the efficiency impact. Note the efficiency change depends on the type of expansion valve. Use the curve labeled TXV for units with thermal expansion valves, otherwise use the curve labeled short orifice.



If the magnitude of the charge adjustment is not known, a default value of 10% improvement in unit efficiency is recommended. That is, the efficiency of an uncorrected unit is 10% below that of a corrected unit.

Compliance Efficiency from which Incentives are Calculated

Charge corrected to manufacturers" specifications, restoring unit to nameplate efficiency.

Operating Hours

The operating hours by climate zone and building type are shown in Appendix G.

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit seasonal and peak efficiency data taken from ASHRAE 90.1-2007.
2. Efficiency change as a function of charge adjustment curve taken from *Small HVAC System Design Guide*, New Buildings Institute, White Salmon, WA for the California Energy Commission.

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AIR CONDITIONER – UNITARY

Measure Description

One or more factory-made assemblies that include an evaporator/cooling coil, a compressor and a condenser combination. A unitary AC/HP can be split or packaged system and can be a split or packaged system and can include roof top units (RTU"s) and packaged terminal air conditioners (PTACs)[57]

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Energy Savings

$$\Delta kWh = units \times (tons/units) \times [(12 / SEER_{baseline}) - (12 / SEER_{ee})] \times EFLH_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times (tons/units) \times [(12 / EER_{baseline}) - (12 / EER_{ee})] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

Δ kWh	= Annual electric energy savings
Δ kW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
CF	= Coincidence factor
SEER	= Seasonal energy efficiency ratio in BTU/watt-hour. Total cooling output of an air conditioner during its normal annual usage period for cooling, in BTU/h, divided by the total electric energy input during the same period, in watt-hours
EER	= Energy efficiency ratio, measurement of cooling capacity for a unit (in BTU/hour) / electrical energy used (watts) at a specific temperature of (95^{o}F)
$EFLH_{cooling}$	= Cooling equivalent full-load hours
CF	= Coincidence factor
12	= kBTUh/ton of air conditioning capacity

[57] Based on 2012 ASHRAE Handbook

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application, use 5 tons if unknown
$EER_{baseline}$		Lookup based on unit type and size
EER_{ee}		From application
$SEER_{baseline}$		Lookup based on unit type and size
$SEER_{ee}$		From application
$EFLH_{cooling}$		Lookup based on building type and location
Type		From application
Building type		From application

The ***SEER*** is an estimate of the seasonal energy efficiency for an average US city for small units < 65,000 BTUh cooling output. Larger units are rated by either IPLV (Integrated Part Load Value) or IEER (Integrated Energy Efficiency Ratio). For units larger than 65,000 BTUh cooling output, IEER replaces SEER in the above equation. IEER should be used in lieu of IPLV when available.

The ***EER*** is the rated full-load efficiency of the unit. It is used to estimate of the efficiency of the unit under peak summer conditions.

Coincidence Factor (CF)

Recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Baseline performance efficiency assumptions for new construction and normal replacement vary by equipment size, and are shown in the Table below:

Equipment Category	Capacity Range (BTU/hr)	Baseline Efficiency	
		Average	Peak
Unitary A/C (1) phase	<65,000 1 Ph	13.0 SEER	11.1 EER
Unitary A/C (3) phase	<65,000 3 Ph	13.0 SEER	11.1 EER
Unitary A/C (3) phase	65,000 - 135,000	11.2 IEER	11.0 EER
Unitary A/C (3) phase	135,000 - 240,000	11.0 IEER	10.8 EER
Unitary A/C (3) phase	240,000 - 760,000	9.9 IEER	9.8 EER
Unitary A/C (3) phase	>760,000	9.6 IEER	9.5 EER
Unitary HP (1) phase	<65,000 1 Ph	13.0 SEER	11.1 EER
Unitary HP (3) phase	<65,000 3 Ph	13.0 SEER	11.1 EER
Unitary HP (3) phase	65,000 - 135,000	11.0 IEER	10.8 EER
Unitary HP (3) phase	135,000 - 240,000	10.4 IEER	10.4 EER
Unitary HP (3) phase	240,000 - 760,000	9.3 IEER	9.3 EER
Unitary HP (3) phase	>760,000	9.3 IEER	9.3 EER

Compliance Efficiency from which Incentives are Calculated

Based on program requirements.

Operating Hours

Cooling 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 CLH for eight building types and seven different cities in NY are shown in Appendix G.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit seasonal and peak efficiency data taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

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<u>CHILLER – AIR AND WATER COOLED</u>

Measure Description

Air-cooled and water cooled chillers in commercial buildings with built-up HVAC systems.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times tons/unit \times (IPLV_{baseline} - IPLV_{ee}) \times EFLH_{cooling}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times tons/unit \times (kW/ton_{baseline} - kW/ton_{ee}) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
tons/unit	= Tons of air conditioning per unit, based on nameplate data
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
EFLH	= Equivalent full-load hours
CF	= Coincidence factor
IPLV	= Integrated part-load value
kW/ton	= Full load chiller efficiency under peak conditions

Summary of Variables and Data Sources

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:

$$kW/ton = 3.517 / COP$$

$$IPLV(kW/ton) = 3.517 / IPLV(COP)$$

Variable	Value	Notes
tons		From application
$COP_{baseline}$		Coefficient of performance, ratio of output energy/input energy For baseline measure, lookup based on chiller type and size
COP_{ee}		Coefficient of performance, ratio of output energy/input energy for energy efficient measure, from application
$IPLV_{baseline}$		Integrated part-load value (kW/ton) for baseline, lookup based on chiller type and size
$IPLV_{ee}$		Integrated part-load value (kW/ton) for energy efficient measure, lookup based on chiller type and size, from application
3.517		Conversion factor, one ton equals3.516853 kilowatts
$EFLH_{cooling}$		Cooling equivalent full-load hours, lookup by city building type and HVAC type
Chiller type		Air-cooled, water cooled reciprocating, water cooled screw and scroll, water cooled Centrifugal, from application
Building type		From application; use cross reference table as needed
HVAC type		From application

Coincidence Factor (CF)

Recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

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

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 reciprocating	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

Compliance Efficiency from which Incentives are Calculated

Base on program eligibility criteria.

Operating Hours

Cooling equivalent full-load hours (EFLH) were calculated from a DOE-2.2 simulation of prototypical large office building. The prototype building characteristics are described in Appendix A. The $EFLH_{cooling}$ for built-up HVAC systems in commercial buildings by climate zone and building type are shown in the Appendix G.

Effective Useful Life (EUL)

Years: 20
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Baseline unit seasonal and peak efficiency data taken from ASHRAE Standard 90.1-2007.

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CHILLER - COOLING TOWER

Measure Description

Close approach cooling towers applied to water cooled chillers. The cooling tower is over-sized to provide a condenser water temperature approach to wet-bulb of 6°F at design conditions.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times cooling\ tons \times (\Delta kWh/ton)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times cooling\ tons \times (\Delta kW/ton) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times cooling\ tons \times (\Delta kWh/ton)$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
cooling tons = Size of cooling system retrofitted with a close approach tower
ton = Ton of air conditioning
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh/ton		Electricity consumption savings per ton of cooling system retrofitted with close approach tower, lookup based on building type, HVAC type and location
ΔkW/ton		Summer peak demand savings per ton of cooling system retrofitted with close approach tower, lookup based on building type, HVAC type and location
Cooling tons		From application
Building type		From application; use cross reference table as needed
HVAC type		From application

Unit energy savings were calculated from a DOE-2.2 simulation of commercial buildings with built-up HVAC systems. The prototype building characteristics are described in Appendix A. The unit energy savings by building type across different cities in NY are shown in Appendix J.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be a standard cooling tower with a 10°F approach temperature under standard rating conditions.

Compliance Efficiency from which Incentives are Calculated

The measure is assumed to be a close approach cooling tower with a 6°F approach temperature under standard rating conditions.

Operating Hours

The HVAC system operating hours vary by building type. See Appendix A.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. The measure addresses approach temperature only. Changes in condenser water set point control strategies are not included.

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DUCT - SEALING AND INSULATION

Measure Description

Improvements to duct systems made separately or in conjunction with high efficiency rooftop AC or heat pump and/or furnace installation. Duct systems are assumed to be located in an unconditioned plenum space between insulated finished ceiling and roof surface.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \Bigg[\frac{ton}{unit} \times \frac{12}{SEER} \times EFLH_{cooling} \times \left[1 - \frac{\overline{\eta}_{dist,baseline}}{\overline{\eta}_{dist,ee}}\right]_{cooling} +$$

$$\frac{kBTUh_{out}}{unit} \times \frac{EFLH_{heating}}{HSPF} \times \left[1 - \frac{\overline{\eta}_{dist,baseline}}{\overline{\eta}_{dist,ee}}\right]_{heating} \Bigg]$$

Peak Coincident Demand savings

$$\Delta kW = units \times tons/unit \times \frac{12}{EER_{pk}} \times \left[1 - \frac{\eta_{dist,pk,base}}{\eta_{dist,pk,ee}}\right] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \frac{kBTUh_{in}}{unit} \times \frac{EFLH_{heating}}{100} \times \left[1 - \frac{\overline{\eta}_{dist,baseline}}{\overline{\eta}_{dist,ee}}\right]_{heating}$$

where:

Δ kWh = Annual electric energy savings
Δ kW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
kBTUh = Annual gas input rating
kBTUh = Annual Gas output rating
baseline = Baseline condition or measure
ee = Energy efficient condition or measure
in = Input
out = Output
pk = Peak
dist = Distribution
cooling = Cooling system

heating	= Heating system
tons/unit	= Tons of air conditioning per unit, based on nameplate data
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
EER_{pk}	= Energy efficiency ratio under peak conditions
HSPF	= Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt/hr)
$\bar{\eta}$	= Average energy efficiency (0 -100%)
η	= Energy efficiency (0 -100%)
EFLH	= Equivalent full-load hours
CF	= Coincidence factor
100	= Conversion factor, (kBTUh/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
SEER	10	Existing unit
	13	New construction
$\bar{\eta}_{dist, baseline}$		Value for 30% leakage by building type and location. Use measured leakage if available
$\bar{\eta}_{dist, ee}$		Measured leakage OK if available; otherwise assume 15% in existing systems and 6% in new construction. Use appropriate R-value if duct insulation is also included.
$EFLH_{cooling}$		Vintage weighted average by city.
$EER_{baseline}$	9.2	existing unit
	11.1	new unit
$\eta_{dist, baseline}$	$\bar{\eta}_{dist, baseline}$	
$\eta_{dist, ee}$	$\bar{\eta}_{dist, ee}$	
If heat pump:		
$kBTUh/unit_{out}$		From application
HSPF	6.8	existing unit
	8.1	new unit
If furnace		
$kBTUh_{in}/unit$		From application
$\bar{\eta}_{dist, baseline}$		Value for 30% leakage by building type and location. Use measured leakage if available
$\bar{\eta}_{dist, ee}$		Measured leakage OK if available; otherwise assume 15% in existing systems and 6% in new construction. Use appropriate R-value if duct insulation is also included.
$EFLH_{heating}$		Vintage weighted average by city.

The SEER is an estimate of the seasonal energy efficiency for an average US city. The **EER_{pk}** is an estimate of the efficiency of the unit under peak summer conditions. See the section on packaged air conditioners for more information.

The HSPF is an estimate of the seasonal heating energy efficiency for an average US city. See section on air source heat pumps above for more information.

The ***average seasonal efficiency*** of the furnace is the ratio of the heating output to the fuel input (in consistent units) over a heating season. See section on furnaces for more information.

The ***duct system efficiency*** accounts for losses from duct systems due to leakage and inadequate insulation. Duct system efficiencies were calculated for duct systems located in unconditioned plenum space between an insulated finished ceiling and roof surface in commercial building with packaged rooftop HVAC systems are shown in Appendix H.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for air conditioners, heat pumps and/or furnaces should be set to according to the sections on this equipment above. Distribution system efficiency ($\overline{\eta}_{\text{dist, baseline}}$) should be set as follows:

Overall baseline duct leakage is assumed to be 30%, based on work done by Modera and Proctor on small commercial buildings in California. The baseline duct system is assumed to be uninsulated.

Compliance Efficiency from which Incentives are Calculated

The measure efficiency ($\overline{\eta}_{\text{ee}}$) for air conditioners, heat pumps and/or furnaces should be set according to the sections on this equipment above. The improved duct system efficiency ($\overline{\eta}_{\text{dist, ee}}$) should be set assuming 15% total leakage in existing construction and 8% total leakage in new construction, with R-6 duct insulation.

Operating Hours

Heating equivalent full-load hours calculated from building energy simulation models described in Appendix A and summarized in Appendix G.

Effective Useful Life (EUL)

Years: 18
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. For the purposes of this Tech Manual, duct efficiency calculations should only be done on buildings with duct systems located in unconditioned plenum spaces.
2. Typical duct leakage values in small commercial buildings can be found in Modera, M. and J. Proctor, 2002. *Combining Duct Sealing and Refrigerant Charge Testing to Reduce Peak Electricity Demand in Southern California*, Final Project Report for Southern California Edison.
3. The fraction of the duct leakage assumed to be made up with outside air is 0.50. See: Cummings, J.B., C.R. Withers, N. Moyer, P. Fairey, and B. McKendry. 1996. "Uncontrolled Air Flow in Non–Residential Buildings; Final Report" FSEC-CR-878-96 Florida Solar Energy Center, Cocoa, FL, April, 1996.

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ECONOMIZER – AIR SIDE, WITH DUAL ENTHALPY CONTROL

Measure Description

An air-side economizer is typically integrated into a central air handling system on packaged rooftop units serving small commercial buildings. With ducting for both intake and exhaust, the economizer brings outside air into a building to meet ventilation requirements. Mixing of outside air with exhaust air reduces the heating or cooling load requirements of the building.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times cooling\ tons \times (\Delta kWh/ton)$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
cooling tons = Size of cooling system retrofitted with an economizer
ton = Ton of air conditioning
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh/ton		Electricity consumption savings per ton of cooling system retrofitted with an economizer Lookup based on building type and location
ΔkW/ton		Lookup based on building type and location
tons		From application
Building type		From application; use cross reference table as needed
Location		From application

Dual enthalpy control, often called differential enthalpy, uses similar outdoor air sensor as a single control system, but adds another enthalpy sensor in the return air. The air with the lower enthalpy is brought into the conditioning section of the air handler creating a very efficient method of control. The comparison is continuous, and savings can be verified using psychometric calculations.

Unit energy savings were calculated from a DOE-2.2 simulation of a series of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The unit energy savings by building type and city are shown in Appendix J:

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be a rooftop unit with fixed outside air (no economizer).

Compliance Efficiency from which Incentives are Calculated

Dual enthalpy economizer installed on existing rooftop unit and commissioned to ensure correct operation.

Operating Hours

The HVAC system operating hours vary by building type. See Appendix A.

Effective Useful Life (EUL)

Years: 10
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Dual enthalpy economizers assumed as best available technology for humid applications.

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FURNACE AND BOILER

Measure Description

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 Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$\Delta kWh = N/A$

Peak Coincident Demand Savings

$\Delta kW = N/A$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \left(\frac{\overline{\eta}_{ee}}{\overline{\eta}_{baseline}} - 1\right) \times \left(\frac{EFLH_{heating}}{100}\right)$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
$kBTUh_{in}$	= Annual gas input rating
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
heating	= Heating system
in	= Input capacity
η	= Energy efficiency (0 -100%)
$\overline{\eta}$	= Average energy efficiency (0 -100%)
EFLH	= Equivalent full-load hours
100	= Conversion factor, (kBTUh/therm)

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{in}$/unit		Nominal heating input capacity is the nameplate input rating of the unit in kBTU/hr, from application.
$\overline{\eta}_{baseline}$	See table below	Baseline established by ECCCNYS by equipment type and size
$\overline{\eta}_{ee}$		From application; use units consistent with baseline

Variable	Value	Notes
		efficiency.
$EFLH_{heating}$		Lookup based on building type and location
Building type		From application

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 (E_c) may be used if Et is not available.

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A

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% E_t
Hot Water Boilers	< 300 kBTU/hr	80% AFUE
	≥ 300 – 2500 kBTU/hr	75% E_t and 80%E_c
	> 2500 kBTU/hr	80% E_c
Steam Boilers	< 300 kBTU/hr	75% AFUE
	≥ 300 – 2500 kBTU/hr	75% E_t and 80% E_c
	> 2500 kBTU/hr	80% E_c

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 recommended minimum efficiency for incentives is defined as follows:

Equipment Type	Size Range	Recommended Minimum Efficiency
Furnace	All	Tier 1: 92% AFUE Tier 2: 95% AFUE
Non-Condensing Hot Water	< 300 kBTU/hr	85% AFUE

Boilers	≥ 300 – 2500 kBTU/hr	85% E_t or 88% E_c
	> 2500 kBTU/hr	88% E_c
Condensing Hot Water Boilers	< 300 kBTU/hr	90% AFUE
	≥ 300 – 2500 kBTU/hr	90% E_t or 93% E_c
	> 2500 kBTU/hr	93% E_c
Steam Boilers	< 300 kBTU/hr	82% AFUE

Operating Hours

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

Effective Useful Life (EUL)

Years: 20
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

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

References

1. ECCCNYS 2010 based on ASHRAE 90.1-2007

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Heat Pump – Air Source, Package (PTHP)

Measure Description

A Packaged Terminal Heat Pump (PTHP) (also known as a heat pump PTAC) is a type of PTAC that uses a reverse cycle refrigeration system for heating and includes a supplementary heat source. These supplementary heat sources can include hot water, steam, or electric resistance.[58]

Note: only the heating savings is presented here, cooling savings from an efficient heat pump is the same as the cooling savings for an efficient air conditioner.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left(\frac{kBTU_{out}}{unit}\right) \times \left(\frac{1}{HSPF_{baseline}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{heating}$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left(\frac{kBTUh_{out}}{unit}\right) \times \left(\frac{1}{COP_{baseline}} - \frac{1}{COP_{ee}}\right) \times \frac{EFLH}{3.412} \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
COP	= Coefficient of performance, ratio of output energy/input energy
CF	= Coincidence factor
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
heating	= Heating system
out	= Output capacity
HSPF	= Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt/hr)
EFLH	= Equivalent full-load hours

[58] From the Energy Policy and Conservation Act, 42 U.S.C. 6311(10)(B)

3.412 = Conversion factor, one watt/h equals 3.412142 BTU

Summary of Variables and Data Sources

Variable	Value	Notes
$kBTUh_{out}$ / unit		The nominal rating of the heating output capacity of the heat pump in kBTU/hr (including supplemental heaters), from application. Use 105 kBTU/hr if unknown.
$COP_{baseline}$	COP or $HSPF_{baseline}$ /3.412	Lookup based on system size
$HSPF_{baseline}$		Lookup based on system size
COP_{ee}	COP or $HSPF_{baseline}$/3.412	From application
$HSPF_{ee}$		From application
$EFLH_{heating}$		Heating equivalent full-load hours, lookup based on building type and location
Building type		From application; use cross reference table as needed

The equation above is applicable to heat pumps rated by HSPF. For larger heat pumps, the heat pump efficiency will be represented by the rated coefficient of performance (COP):

The HSPF is an estimate of the seasonal heating energy efficiency for an average US city. The COP is equal to the HSPF/3.412. Programs should use the manufacturers" rated HSPF or COP until data can be developed that are more appropriate for NY climates.

Nameplate capacity for heat pumps should include the full heating capacity of the heat pump system, including backup electric resistance heaters.

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for new construction and normal replacement vary by equipment size, and are shown in the table below.

Equipment Type	Size Range	Baseline Heating Efficiency
Unitary HP (1) phase	<65,000 1 Ph	8.1 HSPF
Unitary HP (3) phase	<65,000 3 Ph	8.1 HSPF
Unitary HP (3) phase	65,000 - 135,000	3.2 COP
Unitary HP (3) phase	135,000 - 240,000	3.2 COP
Unitary HP (3) phase	240,000 - 760,000	3.2 COP
Unitary HP (3) phase	>760,000	3.2 COP

Compliance Efficiency from which Incentives are Calculated

Based on program minimum requirements.

Operating Hours

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. Heating equivalent full-load hours vary by building type and city. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit efficiency data taken from ASHRAE Standard 90.1-2007.

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HEATING, VENTILATION AND AIR CONDITIONING (HVAC) – CONTROL

THERMOSTAT - PROGRAMMABLE SETBACK

Measure Description

Programmable setback thermostats applied to air conditioners, heat pumps and/or furnaces and boilers in small commercial buildings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (tons/unit \times \left(\frac{12}{SEER}\right) \times EFLH_{cooling} \times ESF_{cooling}) + (\left(\frac{kBTUh_{out}}{unit}\right) \times \left(\frac{EFLH_{heating}}{HSPF}\right) \times ESF_{heating})$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = units \times \left(\frac{kBTUh_{in}}{unit}\right) \times \frac{EFLH_{heating}}{100} \times ESF_{heating}$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
tons/unit	= Tons of air conditioning per unit, based on nameplate data
heating	= Heating system
cooling	= Cooling system
out	= Output capacity
in	= Input capacity
12	= kBTUh/ton of air conditioning capacity
ESF	= Energy savings factor
SEER	= Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
HSPF	= Heating seasonal performance factor (BTU/watt-hr), a measure of the seasonal average efficiency of the heat pump in the heating mode
EFLH	= Equivalent full-load hours

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application, or use 5 ton as default. Use 0 if no central cooling
$SEER_{baseline}$	10	
$EFLH_{cooling}$		Vintage weighted average by city.
$ESF_{cooling}$	0.09	
If heat pump:		
$kBTUh/unit_{out}$		The nominal rating of the heating output capacity of the heat pump in kBTU/hr (including supplemental heaters), from application.
$HSPF_{baseline}$	6.8	
If furnace:		
$kBTUh_{in}/unit$		The nominal rating of the heating input capacity of furnace or boiler kBTUh, from application.
If boiler:		
$kBTUh_{in}/unit$		From application.
$EFLH_{heating}$		Vintage weighted average by city.
$ESF_{heating}$	0.068	

The SEER is an estimate of the seasonal energy efficiency for an average US city. The $\mathbf{EER_{pk}}$ is an estimate of the efficiency of the unit under peak summer conditions. See the section on packaged air conditioners above for more information.

The HSPF is an estimate of the seasonal heating energy efficiency for an average US city. See section on air source heat pumps above for more information.

The ***average seasonal efficiency*** of the furnace is the ratio of the heating output to the fuel input (in consistent units) over a heating season. See section on high efficiency furnaces above for more information.

The ***nominal rating of the cooling capacity of the air conditioner or heat pump*** should set equal to the rated capacity of all cooling equipment controlled by a setback thermostat in the building.

The ***nominal rating of the heating capacity*** of the furnace should set equal to the rated input capacity of all heating equipment controlled by a setback thermostat in the commercial facility. Nameplate capacity for heat pumps should include the full output heating capacity of the heat pump system, including backup electric resistance heaters.

The ***Energy Savings Factor*** (ESF) is the ratio of the energy savings resulting from installation of a programmable setback thermostat to the annual cooling energy.

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for air conditioners and heat pumps should be set to according to the sections on air conditioner and heat pump efficiency above.

Studies of residential heating thermostat set point behavior indicate some amount of manual setback adjustment in homes without programmable thermostats. This behavior is assumed to be present in the small commercial buildings addressed in this Tech Manual.

Compliance Efficiency from which Incentives are Calculated

The energy savings factor (ESF) assumption is taken from a study of programmable thermostat savings in Massachusetts conducted by GDS Associates for KeySpan Energy Delivery. The study estimated an energy savings of 3.6% of the annual heating energy consumption for programmable setback thermostats in residential applications. This assumption is also applied to the small commercial buildings addressed in this Tech Manual.

Operating Hours

Heating equivalent full-load hours calculated from building energy simulation models described in Appendix A and summarized in Appendix G.

Effective Useful Life (EUL)

Years: 11
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Energy Saving Factor for setback thermostats taken from "Programmable Thermostats. Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness," GDS Associates, Marietta, GA. 2002.

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LIGHTING

INTERIOR AND EXTERIOR LAMPS AND FIXTURES

Measure Description

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.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times FLH \times (1 + HVAC_c)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

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

New construction, space renovations or remodels may require a building permit that includes compliance with local or state energy codes. In these instances, the applicable energy code defines the baseline. The energy consumption of the efficient and baseline lighting systems are defined in terms of the lighting power density (LPD) in watts per square foot. An alternate form of the lighting equations based on LDP is as follows:

Annual Electric Energy Savings

$$\Delta kWh = units \times area \times \left[\frac{(LPD)_{baseline} - (LPD)_{ee}}{1{,}000}\right] \times FLH \times (1 + HVAC_g)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times area \times \left[\frac{(LPD)_{baseline} - (LPD)_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Gas Energy Savings

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

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor
ee	= Energy efficient condition or measure
baseline	= Baseline condition or measure
area	= Extent of space or surface
1,000	= Conversion factor, one kW equals 1,000 watts
LPD	= Lighting power density
W	= Watts
FLH	= Full-load hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption

Summary of Variables and Data Sources

Variable	Value	Notes
$Units_{baseline}$		Number of baseline measures, from application, set equal to $Units_{ee}$ if unknown
$Units_{ee}$		Number of energy efficient measures installed under the program, from application.
W_{ee}	Watts	Connected load of the energy-efficient unit, from application
$W_{baseline}$	Watts	Connected load of the baseline unit(s) displaced, from application
FLH		From application or default table in Manual
$LPD_{baseline}$		Lighting power density (W/SF) for baseline measure, from application, based on NY State Energy Conservation code. New construction or major renovation only.
LPD_{ee}		Lighting power density (W/SF) for energy efficient measure, from application, based on installed system design. New construction or major renovation only.
area		floor area illuminated by lighting system (SF)
$HVAC_d$		HVAC interaction factor at utility summer peak hour, lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption, lookup by building type with weighted

Variable	Value	Notes
		average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
$HVAC_g$		HVAC interaction factor for annual natural gas consumption, lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
Building type		From application.
City		From application
Fixture location	Indoor, outdoor	From application; assume indoor if not known

$\textbf{Watts}_{\textbf{ee}}$ 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.

$\textbf{Watts}_{\textbf{baseline}}$ 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 that trigger the building code. See table of standard fixture wattages in Appendix C.

Code LPD shall be taken from New York State Energy Conservation Code that is based on ASHRAE 90.1-2007. Use the appropriate LPD based on the building type or space occupancy as applicable.

Coincidence Factor (CF)

Defined as the ratio of the peak lighting demand operating at the time of the system peak to the connected load. Because not all of the fixtures in the population are operating at all times, the peak lighting demand is often less than the connected load. Occupant control of the lighting systems and burned-out lamps cause some portion of the fixtures to be non-operational. In lighting retrofit programs, the pre-retrofit (baseline) demand diversity factor is often lower than the post-retrofit demand diversity factor, due to burned out lamps that are replaced as part of the program.

For many utilities, summer peak demand occurs in the afternoon, indicating a recommended value for the coincidence factor for interior lighting is 1.0, and since exterior lighting is generally off during daylight hours, the recommended value is 0.0

The ***HVAC system interaction factor*** is defined as the ratio of the cooling energy reduction per unit of lighting energy reduction. Most of the input energy for lighting systems is converted to heat that must be removed by the HVAC system. Reductions in lighting heat gains due to lighting power reduction decrease the need for space cooling and increase the need for space heating. HVAC interaction factors vary by climate, HVAC system type and building type. Recommended values for HVAC interaction factors for lighting energy and peak demand savings are shown in Appendix D. Lighting systems in unconditioned spaces or on the building exterior will have interaction factors of 0.0. The building types for the HVAC interactive effect factors by facility type are shown in the lighting FLH table above.

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 that trigger the building code. See table of standard fixture wattages in Appendix C. Note, depending on local codes, new construction, space renovations or remodels may require a building permit that includes compliance with local or state energy codes. In these instances, the applicable energy code defines the baseline.

Compliance Efficiency from which Incentives are Calculated

Efficient lighting fixtures as defined by the program. See table of standard fixture wattages in Appendix C. Manufacturers‟ cut sheets may substitute for the standard fixture watts in Appendix C if available. In new construction or major renovation projects, the new lighting system power consumption should be expressed as a lighting power density (LPD) in watts per square foot.

Operating Hours

The average ***full-load hours*** are defined by building type, as shown in the table below. These are typical average values for the building types shown. Use building specific operating hours where available.

Facility Type	Lighting Hours	HVAC Int	Facility Type	Lighting Hours	HVAC Int
Auto Related	4,056	AR	Manufacturing Facility	2,857	Ind
Bakery	2,854	FS	Medical Offices	3,748	SOfc
Banks	3,748	SOfc	Motion Picture Theatre	1,954	Asy
Church	1,955	Rel	Multi-Family (Common Areas)	7,665	MFL
College– Cafeteria(1)	2,713	FS	Museum	3,748	Asy
College – Classes/ Administrative	2,586	CC	Nursing Homes	5,840	MFL
College - Dormitory	3,066	Dorm	Office (General Office Types) (1)	3,100	SOfc / LOfc
Commercial Condos(2)	3,100	SOfc	Office/Retail	3,748	SOfc / LOfc
Convenience Stores	6,376	SRet	Parking Garages	4,368	None
Convention Center	1,954	Asy	Parking Lots	4,100	None
Court House	3,748	LOfc	Penitentiary	5,477	MFL
Dining: Bar Lounge/Leisure	4,182	FS	Performing Arts Theatre	2,586	Asy
Dining: Cafeteria / Fast Food	6,456	FF	Police / Fire Stations (24 Hr)	7,665	Asy
Dining: Family	4,182	FS	Post Office	3,748	SRet

Facility Type	Lighting Hours	HVAC Int	Facility Type	Lighting Hours	HVAC Int
Entertainment	1,952	Asy	Pump Stations	1,949	Ind
Exercise Center	5,836	SRet	Refrigerated Warehouse	2,602	RWH
Fast Food Restaurants	6,376	FF	Religious Building	1,955	Rel
Fire Station (Unmanned)	1,953	Asy	Restaurants	4,182	FS
Food Stores	4,055	Gro	Retail	4,057	SRet / LRet
Gymnasium	2,586	Asy	School / University	2,187	Univ
Hospitals	7,674	Hosp	Schools (Jr./Sr. High)	2,187	HS
Hospitals / Health Care	7,666	Hosp	Schools (Preschool/Elementary)	2,187	Sch
Industrial - 1 Shift	2,857	Ind	Schools (Technical/Vocational)	2,187	CC
Industrial - 2 Shift	4,730	Ind	Small Services	3,750	SOfc
Industrial - 3 Shift	6,631	Ind	Sports Arena	1,954	Asy
Laundromats	4,056	SRet	Town Hall	3,748	Asy
Library	3,748	LOfc	Transportation	6,456	Asy
Light Manufacturers(1)	2,613	Ind	Warehouse (Not Refrigerated)	2,602	WH
Lodging (Hotels/Motels)	3,064	Hotel/ Motel	Waste Water Treatment Plant	6,631	Ind
Mall Concourse	4,833	LRet	Workshop	3,750	Ind

(1) FLH data from the 2008 California DEER Update study
(2) FLH data for offices used

Effective Useful Life (EUL)

Measure	Years	Source
CFL Lamp	9,000 hours /annual operating hours	See note below
CFL Light Fixture	12	DEER
Interior & Exterior, including linear fluorescent	70,000 hours /annual operating hours or 15 years (whichever is less)	DEER
Interior Dry Transformers	25	Conservative estimate based on DOE value
LEDs Fixtures and Screw-In Lamps (other than refrigerated case)	35,000 or 50,000 hours	DLC
	35,000 hours	Energy Star
	15,000 hours(decorative) or 25,000 (all other)	Energy Star
	25,000 hours	Uncertified
Refrigerated Case LED	6	NW RTF

Ancillary Fossil Fuel Savings Impacts

Reduction in lighting power increases space heating requirements. Interactions with the heating system must be applied to the calculations as shown in the equations above.

Ancillary Electric Savings Impacts

References

1. Lighting operating hour data taken from the CL&P and UI Program Savings Documentation for 2008 Program Year, with exceptions as noted.
2. Additional lighting operating hour data taken from 2008 DEER Update – Summary of Measure Energy Analysis Revisions, August, 2008. Available at www.deeresources.com

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REFRIGERATED CASE LED

Measure Description

This measure pertains to installation of LED lamps in commercial display refrigerators, coolers or freezers. The display lighting in a typical cooler or freezer add to the load on that unit by increasing power consumption of the unit when the lamp is on, and by adding heat to the inside of the unit that must be overcome through additional cooling. Replacing fluorescent lamps with low heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of waste heat generated from the lamps that must be overcome by the unit"s compressor cycles.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (lighting\ kWh_{baseline} - lighting\ kWh_{LED}) + Refrig_{sav}$$

where:

Lighting $kWh_{baseline}$ = Total annual lighting kWh usage of the unit per year with conventional baseline lighting.

Lighting kWh_{LED} = Total annual lighting kWh usage of the units with the LEDs installed.

$Refrig_{sav}$ = kWh savings of the refrigeration unit by not needing to cool the heat generated by the inefficient lighting.

The kWh savings from the compressor not needing to run are calculated as follows:

$$Refrig_{sav} = units \times (Lighting\ kWh_{baseline} - Lighting\ kWh_{LED}) \times Overall\ Comp_{eff}\ (cooler\ or\ freezer)$$ [59]

where:

Overall $Comp_{eff\text{-}cooler}$ = Overall compressor efficiency for cooler factoring in portion of saved energy eliminated via compressor

Overall $Comp_{eff\text{-}freezer}$ = Overall compressor efficiency for freezer factoring in portion of saved energy eliminated via compressor

Peak Coincident Demand Savings

$$\Delta kW = units \times (kW_{baseline} - kW_{LED}) \times (1 + Comp_{factor})$$

where:

Lighting $kW_{baseline}$ = Total power usage of lighting fixtures being replaced

Lighting kWh_{LED} = Total power usage of new lighting fixtures are being installed.

$Comp_{factor\text{-}cooler}$ = Compressor factor for cooler.

$Comp_{factor\text{-}freezer}$ = Compressor factor for freezer

[59] It is assumed that 0.2 of the saved energy escapes via conduction through display case and does not have to be recaptured by the compressor.

Run hours per year adjusted for lighting controls; specify hours per day controlled off.

Summary of Variables and Data Sources

Variable	Value	Notes
Lighting $kWh_{baseline}$		Total lighting run hours per year × wattage of baseline lighting, use 2 × LED watts as default
Lighting kWh_{LED}		Total lighting run hours per year × wattage of LED lighting.
Overall $Comp_{eff\text{-}cooler}$	0.41	Value is calculated by multiplying 0.51 (Compressor efficiency for cooler) by 0.8 (Portion of saved energy eliminated via the compressor.
Overall $Comp_{eff\text{-}freezer}$	0.52	Value is calculated by multiplying 0.65 (Compressor efficiency for cooler) × 0.80 (Portion of saved energy eliminated via the compressor.
$Comp_{factor\text{-}cooler}$	0.40	Based on EER value of 1.8 kW/ton × 0.285 ton/kW × 0.8 (20% of case lighting load not converted into case cooling load) = 0.40
$Comp_{factor\text{-}freezer}$	0.51	Based on EER value of 2.3 kW/ton × 0.285 ton/kW × 0.8 (20% of case lighting load not converted into case cooling load) = 0.51

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

The savings approach is based on the estimated difference in refrigerator / cooler / freezer consumption before the change-out compared to the unit consumption after the change-out for the period of time the unit is turned on during a typical year of operation.

Typical applications of LED case lighting are shown below

Measure description	Baseline	Measure watts	Baseline watts	Fixture savings
5 foot LED case light	5 ft T8 lamp with normal light output	38	76	38
6 foot LED case light	6 ft T12lamp with high light output	46	112	66

Compliance Efficiency from which Incentives are Calculated

Operating Hours:

Based on Application.

Effective Useful Life (EUL)

Years: 6
Source: NW RTF

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Typical LED applications from Pacific Gas and Electric LED Refrigerated Lighting fact sheet. These applications span the range from low to high savings. 50% savings conservative value based on T8 normal light output baseline.

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LIGHTING – CONTROL

INTERIOR LIGHTING CONTROL

Measure Description

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.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

$$\Delta kW = units \times (W_{ctrl} / 1{,}000) \times (1 + HVAC_d) \times DSF \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times \Delta kWh \times HVAC_g$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
1,000	= Conversion factor, one kW equals 1,000 watts
W	= Watts
ctrl	= Control
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
CF	= Coincidence factor
DSF	= Demand savings factor
FLH	= Full-load operating hours
$HVAC_c$	= HVAC interaction factor for annual electric energy consumption
$HVAC_d$	= HVAC interaction factor at utility summer peak hour
$HVAC_g$	= HVAC interaction factor for annual natural gas consumption

Summary of Variables and Data Sources

Variable	Value	Notes
units		Number of measures installed under the program, from application
W_{ctrl}	Watts	Connected load of controlled lighting fixtures, from application
Control type		From application
$FLH_{baseline}$		From application
FLH_{ee}		From application
$HVAC_d$		HVAC interaction factor at utility summer peak hour, Lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
$HVAC_c$		HVAC interaction factor for annual electric energy consumption, lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
$HVAC_g$		HVAC interaction factor for annual natural gas consumption, lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
Building type		From application.
City		From application
Fixture location	Indoor, outdoor	From application; assume indoor if not known

The ***demand savings factor*** (DSF) is the maximum hourly reduction in lighting demand achieved by a particular control measure. Lighting controls save energy and demand by reducing or shutting off power input to lighting fixtures in response to a control signal. Demand savings can be achieved by the following controllers and their respective control actions:

- Occupancy sensors - Switching off lights when the space is unoccupied.
- Daylight sensing controls - Reducing electric lighting levels according to the availability of daylight.
- Dimming controls - Reducing lighting levels to suit the occupant.
- Time clocks - Switching off lights according to a fixed schedule.
- Photocells - Controlling outdoor lights according to the availability of daylight. These may be combined with time clock control.
- Programmable control systems - Sophisticated lighting controllers that combine many of the above functions into a single unit and may also be coupled to the building security system.

Coincidence Factor (CF)

Defined as the ratio of the peak lighting demand operating at the time of the system peak to the connected load. Because not all of the fixtures in the population are operating at all times, the peak lighting demand is often less than the connected load. Occupant control of the lighting systems and burned-out lamps cause some portion of the fixtures to be non-operational. In lighting retrofit programs, the pre-retrofit (baseline) demand diversity factor is often lower than the post-retrofit demand diversity factor, due to burned out lamps that are replaced as part of the program.

For many utilities, summer peak demand occurs in the afternoon, indicating a coincidence factor of 1.0 for commercial indoor lighting measures. Since exterior lighting is generally off during daylight hours, the coincidence factor for exterior lighting is 0.0.

See Appendix D for HVAC interaction factors.

Baseline Efficiencies from which Savings are Calculated

Baseline calculations assume no lighting controls are installed, except those required by local energy code as applicable.

Compliance Efficiency from which Incentives are Calculated

Lighting controls designed and installed in accordance with manufacturers" and/or designer recommendations.

Operating Hours

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:

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

where:

ESF	= energy savings factor
FLH	= full-load operating hours
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure

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

Effective Useful Life (EUL)

Years: 8
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Reduction in lighting power increases space heating requirements. Interactions with the heating system must be applied to the calculations, as described above.

Ancillary Electric Savings Impacts

References

1. Energy and demand savings factors derived from lighting control power adjustment factors prescribed in the California Title 24 Nonresidential lighting standards.

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1	10/15/2010

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MOTORS AND DRIVES

MOTOR REPLACEMENT

Measure Description

NEMA premium efficiency motors replacing standard efficiency motors in commercial and industrial applications.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times 0.746 \times \left[\left(\frac{hp_{baseline} \times RLF_{baseline}}{\eta_{baseline}}\right) - \left(\frac{hp_{ee} \times RLF_{ee}}{\eta_{ee}}\right)\right] \times FLH$$

Peak Coincident Demand Savings

$$\Delta kW = units \times 0.746 \times \left[\left(\frac{hp_{baseline} \times RLF_{baseline}}{\eta_{baseline}}\right) - \left(\frac{hp_{ee} \times RLF_{ee}}{\eta_{ee}}\right)\right] \times CF$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
η	= Energy efficiency (0 -100%)
$_{baseline}$	= Baseline condition or measure
$_{ee}$	= Energy efficient condition or measure
hp	= Horsepower
FLH	= Full-load hours
RLF	= Rated load factor
CF	= Coincidence factor
0.746	= Conversion factor (kW/hp), 746 watts equals one electric horsepower

Summary of Variables and Data Sources

Variable	Value	Notes
$\eta_{baseline}$		Efficiency of baseline measure
η_{ee}		Efficiency of energy efficient measure
$hp_{baseline}$		Horsepower rating of baseline motor
hp_{ee}		Horsepower rating of energy efficient measure

Variable	Value	Notes
$RLF_{baseline}$		Rated load factor of baseline motor
RLF_{ee}		Rated load factor of energy efficient motor

The ***motor horsepower*** refers to the nameplate or rated power output of the motor. Motors are commonly over-sized for the loads served. An energy efficient motor with a lower nameplate horsepower rating may be installed to correct for over-sizing.

The ***rated load factor*** is the ratio of peak running load to nameplate rating of the motor. The rated load factor for the energy-efficient motor will be greater than the rated load factor of the base case motor if a smaller energy-efficient motor is used to correct for over-sizing. If a smaller motor is installed, but the shaft power requirements stay the same, the product of the rated horsepower and the rated load factor should be constant. Lower torque from efficient motors may prevent downsizing of the motor.

$$(RLF \times hp)_{baseline} = (RLF \times hp)_{ee}$$

Motor ***full-load hours*** are defined as the total annual energy consumption divided by the peak hourly demand.

$$FLH = \frac{kWh}{kW_{max}}$$

For loads that do not vary with time (i.e., a motor driving a constant load), full-load hours are simply equal to the operating hours. Efficient motors generally run at slightly higher RPM than standard motors. Unless the motor drive system is modified to correct for higher RPM operation, the power delivered by the motor may increase. The increase in power delivery may negate the effects of improved efficiency.

Coincidence Factor (CF)

The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Former NEMA premium efficiency motors now standard efficiency due to changes in Federal standards. See Appendix L for a list of baseline motor efficiency requirements.

Compliance Efficiency from which Incentives are Calculated

Must exceed new Federal standards.

Operating Hours

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Motor operating hour data taken from the CL&P and UI Program Savings Documentation for 2008 Program Year.
2. The Energy Independence and Security Act (EISA) of 2007 established NEMA Premium as the new standard for all motors.

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VARIABLE FREQUENCY DRIVE – FAN AND PUMP

Measure Description

Variable frequency drives applied to fans and pumps in commercial and industrial buildings.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
hp = Horsepower
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
hp		Horsepower rating of motor controlled by VFD, from application
ΔkW/hp		Peak demand savings from VFD per hp of motor controlled, lookup by building type, city and VFD application. If building type not listed, use building type = other
ΔkWh/hp		Annual energy savings from VFD per hp of motor controlled, lookup by building type, city and VFD application. If building type not listed, use building type = other
Building type		From application

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.

Coincidence Factor (CF)

The CF is used to account for the fact that not all motors with VFDs 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 motors with VFDs that are operating at the time of the system peak. The recommended value for the coincidence factor is 0.8

Baseline Efficiencies from which Savings are Calculated

Applications covered in this section are; AHU supply and return fans, CHW pumps, cooling tower fans, condenser water pumps, heating hot water pumps, HVAC exhaust fans, process exhaust or make-up air fans, process cooling pump, boiler draft fans, water supply or waste-water pumps, boiler feed-water pumps

The baseline system characteristics by application are as follows:

- Chilled water and hot water pumps:
  - Variable volume, constant speed secondary pumping system assumed as the baseline.
    - Existing pump rides pump curve as flow varies.
- Supply fans:
  - VAV system with inlet vane control.
- Return fans:
  - VAV system with discharge damper control.
- Cooling tower fans:
  - One speed constant volume fan.
- Condenser water pumps:
  - Constant speed, constant flow condenser water pumps.

Compliance Efficiency from which Incentives are Calculated

- Chilled water and hot water pumps:
  - Variable volume, variable speed secondary pumping system.
- Supply fans:
  - VAV system with VFD control.
- Return fans:
  - VAV system with VFD control.
- Cooling tower fans:
  - Variable speed fans controlling condenser water temperature to 85°F.
- Condenser water pumps:
  - Variable speed, variable flow condenser water loop.

Operating Hours

See Appendix A for a description of the commercial building prototypes.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Unit savings for VFD measures taken from NEEP data forwarded by National Grid. See Chan, T. *Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR.* June 2010.
    a. These values were trued up to National Grid evaluation studies by computing the ratio of the savings by VFD application from the National Grid Massachusetts Energy Initiative program evaluation to the average value by application across the NSTAR data. This adjustment factor was then applied to each of the NSTAR values. See Demand Management Institute, *Prescriptive Variable Speed Drive Worksheet Development.* June, 2006.

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REFRIGERATION

AIR COOLED REFRIGERATION CONDENSER

Measure Description

Install an efficient, close approach air-cooled refrigeration system condenser. This measure saves energy by reducing condensing temperatures and improving the efficiency of the condenser fan system.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

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

Peak Coincident Demand Savings

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

Annual Gas Energy Savings

Δtherms = N/A

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program
tons/unit = Tons per unit, based on nameplate data of refrigeration system compressor
ΔkWh/ton = Electricity consumption savings per ton of compressor capacity
CF = Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes
tons/unit		Tons per unit, based on nameplate data of refrigeration system compressor, from application
ΔkW/ton		lookup based on upstate average or NYC
ΔkWh/ton		lookup based on upstate average or NYC

Unit ***energy and demand savings*** were calculated from a DOE-2.2 simulation of a prototypical grocery store. The prototype building characteristics are described in Appendix A. The unit energy and demand savings for seven different cities in NY are shown below.

City	Unit	kWh /unit	kW/unit
Albany	per ton of compressor capacity	1296	0.136
Binghamton	per ton of compressor capacity	1290	0.143

City	Unit	kWh /unit	kW/unit
Buffalo	per ton of compressor capacity	1297	0.103
Massena	per ton of compressor capacity	1301	0.123
NYC	per ton of compressor capacity	1220	0.152
Poughkeepsie	per ton of compressor capacity	1258	0.144
Syracuse	per ton of compressor capacity	1283	0.149

Coincidence Factor (CF)

The recommended value for the coincidence factor is 1.0

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to a standard efficiency air-cooled refrigeration system condenser, with a 20ºF approach temperature on low temperature applications and a 15ºF approach temperature on medium temperature applications. Standard efficiency specific fan power of 45 BTU/hr of heat rejection capacity per watt of fan power.

Compliance Efficiency from which Incentives are Calculated

Must provide an efficient air-cooled refrigeration system condenser, with an approach temperature of 13ºF or less on low temperature applications and an approach temperature of 8ºF or less on medium temperature applications. Specific fan power must be greater than or equal to 85 BTU/hr of heat rejection capacity per watt of fan power.

Operating Hours

The refrigeration system is assumed to be operating 24/7.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Measure performance characteristics taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005, available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

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FAN MOTOR – WITH ELECTRONICALLY COMMUTATED (EC) MOTOR, FOR REFRIGERATED CASE OR WALK-IN COOLER

Measure Description

Replacement of refrigerated case motors with electronically commutated (EC) motor, or retrofits of walk-in cooler or freezer motors with EC motors.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

(ECM RETROFITS IN WALK-IN COOLERS AND FREEZERS)

Annual Electric Energy Savings

$$\Delta kWh = units \times (\Delta kWh_{EF} + \Delta kWh_{RH})$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkWh_{EF}	= Savings due to evaporator fan motor replacement
ΔkWh_{RH}	= Savings due to reduced heat from evaporator fan motor replacement
ΔkW	= Peak coincident demand electric savings
$\Delta therms$	= Annual gas energy savings
units	= Number of measures installed under the program

where each component is calculated in the following manner:

$$\Delta kWh_{EF} = units \times \text{savings due to evaporator fan motor replacement}$$

$$\Delta kWh_{EF} = units \times A_{EF} \times V_{EF} \times \sqrt{Phase}_{EF} \times 0.55 \times (8{,}760 \text{ or } 5{,}600) \times 65\% / 1{,}000$$

where:

$_{EF}$	= Evaporator fan
$_{RH}$	= Reduced heat from evaporator fan motor replacement
A_{EF}	= Nameplate amperage of evaporator fan motor
V_{EF}	= Nameplate voltage of evaporator fan motor
$Phase_{EF}$	= Phase of evaporator fan
0.55	= Power factor/adjustment
8,760	= Annual operating hours if cooler control system is not part of the installation
5,600	= Annual operating hours if cooler control system is part of the installation

65% = Reduction of load by replacing motor
1,000 = Conversion factor, one kWh equals 1,000 Wh

and:

ΔkWh_{RH} = units × savings due to reduced heat from evaporator fan motor replacement

$$\Delta kWh_{RH} = units \times \Delta kWh_{EF} \times 0.285 \times 1.6$$

where:
ΔkWh_{EF} = Savings due to evaporator fan motor replacement
0.285 = Conversion factor, one kW equals 0.285388 ton
1.6 = Typical refrigeration system kW/ton

(Refrigerated Case Motor Replacement)

Annual Electric Energy Savings

$$\Delta kWh = units \times (\Delta kWh_{CM} + \Delta kWh_{RH})$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

Δtherms = N/A

where:
ΔkWh = Annual electric energy savings
ΔkWh_{CM} = Savings due to case motor replacement
ΔkWh_{RH} = Savings due to reduced heat from case motor replacement
ΔkW = Peak coincident demand electric savings
Δtherms = Annual gas energy savings
units = Number of measures installed under the program

where each component is calculated in the following manner:

ΔkWh_{CM} = units × savings due to case motor replacement

$$\Delta kWh_{CM} = units \times \text{Annual motor kW A} \times (53\% \text{ or } 29\%) \times 8{,}500$$

where:
$_{CM}$ = Case motor

RH	= Reduced heat from case motor replacement
kW A	= metered load of case motor
53%	= Energy reduction if a shaded pole motor is being replaced
29%	= Energy reduction if a split capacitor motor is being replaced
8,500	= Average run-time of case motors

and:

$$\Delta kWh_{RH} = \text{units} \times \text{savings due to reduced heat from case motor replacement}$$

$$\Delta kWh_{RH} = \text{units} \times \Delta kWh_{CM} \times 0.285 \times 1.6$$

where:

ΔkWh_{CM}	= Savings due to case motor replacement
0.285	= Conversion factor, one kW equals 0.285388 ton
1.6	= Typical refrigeration system kW/ton

Summary of Variables and Data Sources

Variable	Value	Notes
Power factor/ adjustment	0.55	Based on experience of National Resource Management (NRM)
Reduction of load by replacing motors	65%	This 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.
Energy reduction from motor replacement	29%	Energy reduction if a split-capacitor motor is being replaced. Based on numerous pre and post meter readings conducted by NRM.
Energy reduction from motor replacement	53%	Energy reduction if a shaded pole motors is being replaced. Based on numerous pre and post meter readings conducted by NRM.

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A

Baseline Efficiencies from which Savings are Calculated

Compliance Efficiency from which Incentives are Calculated

Operating Hours

The annual operating hours of a walk-in cooler or freezer is 8,760, when a cooler control system is not part of installation. The annual operating hours for a walk-in cooler or freezer when a cooler control system is part of the installation is 5,600.

Effective Useful Life (EUL)

Years: 15
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Power Factor/Adjustment of 0.55, estimate by National Resource Management, based on their experience over the past 15 years.
2. Percent reduction (0.65) of load by replacing motors, estimate by National Resource Management 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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1	10/15/2010
7-13-17	7/31/2013

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Refrigerated Case Night Cover

Measure Description

Night covers installed on medium temperature open multi-deck cases in grocery stores to reduce energy consumption by reducing infiltration into the case during unoccupied hours. The analysis assumes a night cover is deployed 4 hours per night, reducing store air infiltration into the case by 50%, when in use.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times w \times hrs \times F_{case}$$

Peak Coincident Demand Savings

$$\Delta kW = N/A$$

Annual Gas Energy Savings

$$\Delta therms = N/A$$

where:

ΔkWh = Annual electric energy savings
ΔkW = Peak coincident demand electric savings
$\Delta therms$ = Annual gas energy savings
units = Number of measures installed under the program
w = Width of the opening that the covers protect, ft.
hrs = Hours per year the covers are in use.
F_{case} = Energy factor for case

Summary of Variables and Data Sources

Variable	Value	Notes
F_{case}	kW/ft	Savings factor based on the temperature of the case
Low temperature (-35°F to -5°F)	0.1 kW/ft	These savings factor values are recommended based on a study by Southern California Edison[60].
Medium temperature (0°F to 30°F)	0.06 kW/ft	
High temperature (35°F to 55°F)	0.04 kW/ft	

Coincidence Factor (CF)

The recommended value for the coincidence factor is N/A

[60] "Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case" *Southern California Edison Refrigeration Technology and Test Center Energy Efficiency Division* August 8, 1997.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be no night covers installed.

Compliance Efficiency from which Incentives are Calculated

Based on program eligibility requirements.

Operating Hours

The night curtains are assumed to be deployed 4 hours per night.

Effective Useful Life (EUL)

Years: 5
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Measure performance characteristics taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

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Refrigeration - Control

Anti-Condensation Heater Control

Measure Description

Anti-condensation heater controls for glass reach-in doors in grocery store freezer cases reduce energy costs by use of humidity-sensing controls to reduce run time to only when necessary.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Cooler Doors

Annual Electric Energy Savings

$$\Delta kWh = (kWh_{pre\text{-}install\ cooler} - kWh_{post\text{-}install\ cooler})$$

where:

$kWh_{pre\text{-}install\ cooler}$ = Total energy usage of cooler doors prior to installation of anti-condensation heater control

$kWh_{post\text{-}install\ cooler}$ = Total energy usage of cooler doors after installation of anti-condensation heater control

and:

$$kWh_{pre\text{-}install\ cooler} = (kW_{DH\text{-}cooler} \times 8{,}760)$$

$$kWh_{post\text{-}install\ cooler} = (0.60 \times kW_{DH} \times 3{,}760)$$

where:

$kW_{DH\text{-}cooler}$ = Total demand of cooler door heater controls calculated using nameplate volts and amps

Peak Coincident Demand Savings

$$\Delta kW = (kW_{DH\text{-}cooler} \times DH_{time\ off\text{-}cooler} \times Adj_{diversity\text{-}coincidence})$$

where:

$DH_{time\ off\text{-}cooler}$ = Fraction of time cooler heater door is off after installation of anti-condensation heater control

$Adj_{diversity\text{-}coincidence}$ = Estimate of additional adjustment (for coolers and freezers) to account for diversity and peak coincidence.

Freezer Doors

Annual Electric Energy Savings

$$\Delta kWh = (kWh_{pre\text{-}install\ freezer} - kWh_{post\text{-}install\ freezer})$$

where:

$kWh_{pre\text{-}install\ freezer}$ = Total energy usage of freezer doors prior to installation of anti-condensation heater control

$kWh_{post\text{-}install\ freezer}$ = Total energy usage of freezer doors after installation of anti-condensation heater control

and:

$kWh_{pre\text{-}install\ freezer} = (kW_{DH\text{-}freezer} \times 8{,}760)$

$kWh_{post\text{-}install\ freezer} = (.40 \times kW_{DH\text{-}freezer} \times 4{,}000) + (kW_{DH\text{-}freezer} \times 4{,}760 \times 0.65)$

where:

$kW_{DH\text{-}freezer}$ = Total demand of freezer door heater controls calculated using nameplate volts and amps

Peak Coincident Demand Savings

$$\Delta kW = (kW_{DH\text{-}freezer} \times DH_{time\ off\text{-}freezer} \times Adj_{diversity\text{-}coincidence})$$

where:

$DH_{time\ off\text{-}freezer}$ = Fraction of time cooler heater door is off after installation of anti-condensation heater control

Summary of Variables and Data Sources

Variable	Value	Notes
Annual run hours of cooler and freezer door heater prior to installation of anti-condensation heater control.	8,760	
Fraction of total power at which cooler door heater runs after installation of anti-condensation heater control.	0.60	Estimated by National Resource Management (NRM) based on monitoring data collected of door heater controls.
Number of hours at which cooler door heaters run at reduced power fraction of .40	3,760	Estimated by NRM based on monitoring data collected of cooler door heater controls.
$DH_{time\ off\text{-}cooler}$	0.74	Estimated by NRM based on monitoring data collected of cooler door heater controls.
$Adj_{diversity\text{-}coincidence}$	0.75	For coolers and freezers.
Fraction of total power at which freezer door heater runs after installation of anti-condensation heater control.	0.40	Estimated by NRM based on monitoring data collected of freezer door heater controls.
Number of hours at which freezer door heaters run at reduced power fraction of .40.	4,000	Estimated by NRM based on monitoring data collected of freezer door heater controls.
Number of hours at which freezer door heaters run at reduced power fraction of .65	4,670	Estimated by NRM based on monitoring data collected of freezer

Variable	Value	Notes
		door heater controls.
Fraction of total power at which freezer door heater runs after installation of anti-condensation heater control.	0.65	Estimated by NRM based on monitoring data collected of freezer door heater controls.
$DH_{time\ off\text{-}freezer}$	0.46	Estimated by NRM based on monitoring data collected of freezer door heater controls.

Coincidence Factor (CF)

The recommended value for the coincidence factor is included in the above calculations.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed with out anti-condensation heater controls.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

The measure is assumed to operate 24hrs/7days per week, (8,760 hours annual operating hours)

Effective Useful Life (EUL)

Years: 12
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Minor space heating interactions with anti-condensation heater controls will be ignored.

Ancillary Electric Savings Impacts

References

1. Measure performance characteristics taken from the California DEER update study: 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf
2. *Cooler Control Measure Impact Spreadsheet Users' Manual*, Select Energy for NSTAR, March 9, 2004, p.5.

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EVAPORATOR FAN CONTROL

Measure Description

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.

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh\ Evap_{off} + \Delta kWh\ Evap_{reduced} + \Delta kWh\ Comp\_Evap_{ctrl}$$

where:

$\Delta kWh\ Evap_{off}$ = Savings due to Evaporator Fan being off
$\Delta kWh\ Evap_{reduced}$ = Savings due to reduced heat from Evaporator Fans
$\Delta kWh\ Comp\_Evap_{ctrl}$ = Savings due to the electronic controls on compressor and evaporator

$$\Delta kWh\ Evap_{off} = kW_{fan} \times FLH_{fan} \times F_{off}$$

where:

kW_{fan} = Fan kW $(V \times A \times \sqrt{Phase}_{fan} \times PF_{fan}$
V_{fan} = Nameplate fan volts
A_{fan} = Nameplate fan amperage
$Phase_{fan}$ = Number of phases (1 or 3)
PF_{fan} = Power factor for fan motor
FLH_{fan} = Annual operating hours
Fan_{off} = Fraction of time that Evaporator Fan is turned off.

$$\Delta kWh\ Evap_{reduced} = \Delta kWh\ Evap_{off} \times 0.285 \times kW/ton$$

where:

$\Delta kWh\ Evap_{off}$ = Savings due to Evaporator Fan being off.
kW/ton = Compressor efficiency (kW/ton)
0.285 = Conversion factor, one kW equals 0.285388 ton

$$\Delta kWh\ Comp\_Evap_{ctrl} = (kW_{comp} \times ((FLH_W) + (FLH_s)) \times F_{ctrl}) + (kW_{fan} \times FLH_{fan} \times F_{off} \times F_{ctrl})$$

where:

kW_{comp} = Compressor kW $(V_{comp} \times A_{comp} \times \sqrt{Phase}_{comp} \times PF_{comp})$
V_{comp} = Compressor nameplate volts
A_{comp} = Compressor nameplate amps
$Phase_{comp}$ = Number of phases (1 or 3)
PF_{comp} = Power factor for compressor
FLH_s = Compressor summer FLH = $Cycle_{summer} \times hr_{summer}$

FLH_w = Compressor winter FLH = $Cycle_{winter} \times hr_{winter}$
F_{off} = Fraction of time that Evaporator Fan is turned off.
F_{ctrl} = 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)

Peak Coincident Demand Savings

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

Summary of Variables and Data Sources

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
Ton/kW	0.285	Unit conversion
F_{off}	0.352	Estimate by NRM based on downloads of hours of use data from the electronic controller.
kW/ton	1.6	Typical refrigeration system kA/ton
$Cycle_{summer}$	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

Coincident Factor (CF)

The recommended value for the coincident factor is 0.8

Baseline Efficiencies from which Savings are Calculated

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, this estimate approach must be made for the typical units that the program is expected to control.

Compliance Efficiency from which Incentives are Calculated

Operating Hours

Included in formula above

Effective Useful Life (EUL)

Years: 16
Source: DEER

Ancillary Fossil Fuel Savings Impacts

Ancillary Electric Savings Impacts

References

1. Diversity factor taken from "New England Power Service Co. study of Economizers and Evaporator Fan Controls", HEC, June 28, 1996.

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CUSTOM MEASURES

This section is designed to provide New York‟s program administrators (PAs) with additional clarification of the DPS review and oversight procedures for custom measures and applications. The overriding DPS goal is to conduct its oversight responsibilities in a manner that protects ratepayer dollars without unduly limiting the ability of PAs to meet their energy savings goals and administer their programs effectively.

The PAs have the responsibility to develop accurate and unbiased estimates of energy savings of custom projects including addressing quality control, project application review, and energy savings calculations. The processes used by PAs to meet these responsibilities will be reviewed by DPS to ensure accountability and transparency. To minimize the impact on the delivery of services through currently operating programs, PAs may continue to operate their programs while the DPS review process is ongoing.

DEFINITIONS

Quality Control (QC) – Policies and procedures established by the PA to ensure the quality of the energy efficiency measures and services delivered to customers. Quality control activities may include factors such as the minimum requirements for energy calculations, model calibration to billing data, application review criteria, reporting requirements, pre and/or post inspections, measurement and verification (M&V) of energy savings, and qualifications of service providers.

Quality Assurance (QA) – Third party verification activities that ensure QC policies and procedures established by the PAs are working as intended, and provide recommendations for modification of QC policies and procedures as necessary.

Prescriptive Measure – Measure which is offered within specific efficiency programs with a prescribed incentive amount or level for all customers participating in the applicable programs. Not all prescriptive measures are necessarily prequalified (i.e., approved by the DPS for offering within a program).

Prequalified Measure – Measure reviewed for cost-effectiveness by the DPS and approved for offering within a program. All prequalified measures are prescriptive measures, but it is the responsibility of the PAs to ensure that all prequalified measures are cost effective within their programs.

Custom Measure – The traditional definition of a custom measure involves unique, and often complex, technologies and processes installed in large facilities. A detailed engineering analysis is usually required and incentives are offered based on the site-specific expected energy savings and costs. Energy savings are estimated using a site-specific engineering analysis. The engineering analysis technique is chosen based on the measure and facility type with the calculations driven by site and measure-specific data. For our purposes, this category also covers infrequently implemented measures or applications that are not listed in an existing prescriptive program.

EEPS/SBC CUSTOM MEASURES

(Four Categories)

For the EEPS and SBC energy efficiency programs custom measures includes the following four categories:

Measures that are not included in the Tech Manual and are unique to a specific non-standard process or application, as application conditions can substantially change from project to project. For example, this category might include custom industrial processes, snowmaking, and computer chip fabrication facilities.

Measures that are not in category 1, including prescriptive measures that are promoted by the programs, but are not included in the Tech Manual. Examples in this category include EC motors on HVAC system fans and indirect water heaters.

Measures that are in the Tech Manual, but that are installed in a different environment or have a different use conditions than those assumed in the Tech Manual. Examples in this category include certain comprehensive chiller and cooling tower upgrades.

Measures that are in the Tech Manual, but that require simulation modeling or other advanced approaches in order to estimate interactive effects within a facility (if different from category 3). Examples in this category include whole-building performance programs addressing single and multi-family projects and commercial new construction.

CATEGORY 1 – UNIQUE MEASURES/PROJECTS

This section outlines the DPS"s policy for reviewing quality control and quality assurance policies and procedures for programs offering measures unique to a specific non-standard process or application.

Critical review of the project energy savings projections and costs is essential to ensure projects are cost-effective and deliver the expected savings. This is especially important for one-of-a-kind projects, where the savings are large, and the expertise needed to understand and verify energy savings projections is specialized. DPS expects that the PAs will utilize an internal process for reviewing and approving large custom projects including screening for cost-effectiveness. DPS will review this process for completeness and transparency. PAs offering large custom incentive programs must also submit their QC and QA processes to the DPS for review. Any issues resulting from these reviews will be reported to the PAs, along with a list of requirements and a schedule for resolving these issues. The QC and QA functions may be staffed internally or provided by outside contractors. Contractors must possess appropriate certification and demonstrated expertise in the technology or processes proposed for the project. As a component of the QC and QA process review, the qualifications of contractors will be reviewed by the DPS.

If the PA has an existing impact evaluation study capable of informing the energy savings of a custom measure(s), this study may serve as the basis for reporting energy savings, provided the study is reviewed by DPS and meets current EEPS evaluation guidelines and standards.

In order to keep the DPS informed of projects and to assist in its review, the PAs will submit monthly reports showing the progress of all "unique" custom projects in the review and approval pipeline. The report must include a description of customer type and the proposed project, the stage of development, energy and demand savings estimates including baseline assumptions, and the expected approval and construction schedule. The DPS, at its discretion, will review selected projects. The DPS will inform the PAs of its intent to review selected projects and provide the PAs with a review schedule.

As part of the PAs evaluation plan, PAs must conduct impact evaluation on a sample of these custom projects to verify the energy savings claims. Staff may require a project specific impact evaluation for very large projects. Realization rates will be reviewed and possibly revised as evaluation studies provide more data.

CATEGORY 2 – MEASURES INCLUDING PRESCRIPTIVE MEASURES NOT IN THE TECH MANUAL

The DPS understands that PAs are offering, or will be offering, incentives for measures not included in the Tech Manual. It is the responsibility of the PAs to ensure that all measures are cost effective. The DPS will review the calculation procedures used by the PAs to estimate energy savings, set incentive levels, and show cost-effectiveness. The calculation reviews will be used to verify savings claims and cost-effectiveness, reconcile differences between PAs offering similar measures, and along with results from impact evaluations, inform updates of the Tech Manuals.

PAs must submit calculations for review in a timely manner. The DPS will establish a priority for reviewing these calculations based on the expected number of program applications and the expected uncertainty in the energy savings estimates. PAs can report energy savings using their internal estimates prior to the completion of the calculation reviews. Once the reviews are completed and the energy savings adjustments are identified, the DPS will establish a schedule for incorporating the revised energy savings estimates into the reporting process.

CATEGORY 3 – MEASURES IN TECH MANUAL BUT USED IN A DIFFERENT APPLICATION/ENVIRONMENT

The DPS will review the PAs processes for reviewing and approving these custom installations, along with the associated QC and QA policies and procedures. Project review and approval must include a cost-effectiveness screening for each custom project. The QC and QA functions may be staffed internally or provided by outside contractors. Contractors must possess appropriate certification and demonstrated expertise in the technology or processes proposed for the project. As a component of the QC and QA process review, the qualifications of contractors will be reviewed by the DPS.

If the PA has an existing impact evaluation study capable of informing the energy savings of a custom measure(s), this study may serve as the basis for reporting energy saving provided that the study is reviewed by the DPS and the meets current EEPS evaluation guidelines and standards.

The DPS will review procedures used to verify energy savings and approve projects for incentives. Processes used to establish project baselines and energy savings, including engineering analysis tools and simulation software, will be reviewed by the DPS. The DPS may review a sample of project energy savings and cost-effectiveness calculations to check compliance with the approved internal QC processes. Any issues resulting from DPS reviews will be reported to the PAs, along with a list of requirements and a schedule for resolving these issues.

As part of the evaluation plan, PAs must conduct impact evaluations on at least a sample of custom measures to verify the savings claims. Staff may require a project specific impact evaluation for very large projects. Realization rates will be reviewed by the DPS and possibly revised as evaluation studies provide more data.

CATEGORY 4 – WHOLE-BUILDING ANALYSIS

The whole-building approach is commonly applied to new construction projects (both residential and commercial) and specialized retrofit programs such as the Home Performance with Energy Star. These programs use a building energy simulation model to calculate energy savings for a combination or "package" of measures. The building energy simulation models are informed by detailed building audits and may include building diagnostic testing to identify energy savings opportunities.

Many of the PAs have developed internal processes for reviewing and verifying savings estimates developed under the whole-building analysis approach. PAs offering programs utilizing the whole-building approach must submit their QC and QA processes to the DPS for review. Any issues resulting from DPS reviews will be reported to the PAs along with a list of requirements and a schedule for resolving these issues. The QC and QA functions may be staffed internally or provided by outside contractors. Contractors must possess appropriate certification and demonstrated expertise in whole-building performance analysis. As a component of the QC and QA process review, the qualifications of contractors will be reviewed by the DPS.

The DPS will review the processes used to establish project baselines and energy savings estimates, including requirements for calibrating models to measured data or benchmarking results to established energy metrics. This effort will include a review of analysis tools and simulation software including the administrator"s expertise in their application. Evidence of certifications by a third party organization such as the Building Performance Institute or RESNET would be helpful and should be provided by the PA, if available. At the discretion of the DPS, a sample of project energy savings and cost-effectiveness calculations will be reviewed to check compliance with the approved internal QC processes.

Since the measures contained within the package can influence and interact with each other, the whole building analysis gives a good representation of the savings of the overall package of measures, but does not necessarily provide the information needed to understand the contributions of individual measures to the total savings estimate. It is also difficult to isolate the costs of each energy savings measure from the total project cost (especially in new construction projects). As a result, individual measure cost-effectiveness screening is difficult to conduct within a whole-building analysis framework. Although the overall project may be cost effective, there may be "cross subsidies", where highly cost effective measures are compensating for the lack of cost-effectiveness of other measures. Each measure should be cost effective on its own.

As part of the PAs evaluation plan, PAs must conduct impact evaluation on at least a sample of custom projects to verify the savings claims. Staff may require a project specific impact evaluation for very large projects. Realization rates will be reviewed and possibly revised as evaluation studies provide more data.

Recommended Application Review and QC Procedures for Custom Programs

As stated above, the DPS will conduct reviews of the application review and QC procedures in place for custom programs. The following tables provide a list of issues the application review QC procedures for custom programs should address.

Energy Savings Calculations

Issue	Criteria
Baseline definition	List the criteria used to define the project baseline. The DPS will issue further clarification on baseline requirements in a separate document.
Energy savings calculation methods	List acceptable calculation methods, including approved building energy simulation models and other software
Calibration	Define when calculations must be calibrated with measured data. The acceptable sources of measured data should be defined. The calibration statistics in terms of allowable deviation between calculations and measured data should be defined along with allowable adjustment ranges on important input parameters.
Calculations outside of approved tools	When approved tools are required, list restrictions on calculations that can be performed outside of the tools.
Simulation guidelines	Provide general guidance on acceptable modeling practices for building energy simulation models.
Field measurement requirements	List requirements for field measurements that must be taken and included in the measure savings calculation process.

Application Review Process

Issue	Criteria
Program applicability	Check that the application meets each of the program applicability requirements.
Measure cost requirements	Provide guidance on acceptable sources and processes for estimating measure costs. Clarify the need for full measure costs and incremental costs, and breakdowns by labor and materials as required.

Issue	Criteria
Cost-effectiveness calculation method	Provide guidance on how cost-effectiveness calculations should be done, including the required formulas and data sources. Spreadsheets and other software tools conforming to approved cost-effectiveness calculation procedures may be used to meet this requirement.
Consideration of non-energy benefits (NEBs)	Describe requirements for identifying and quantifying expected non-energy benefits as applicable.
Application approval procedures	Describe the application review procedures, including the affiliations and qualifications of reviewers.

Project QC Procedures

Issue	Criteria
Sampling requirements	Describe sampling procedures used to review projects, including numbers of projects reviewed and the distribution of the sample across contractors and consultants. Describe sampling procedures for measures within a particular project as required.
Pre Inspections	Describe requirements for pre-installation inspections, including data collection requirements and the role of pre-installation inspections in the energy savings calculations.
Post inspections	Describe requirements for post-installation inspections, including data collection requirements and the role of post-installation inspections in the energy savings calculations, measure verification and incentive payment release.
Performance testing	Describe requirements for performance testing of measures as a component of post-installation measure installation verification and incentive payment release.
Commissioning	Describe requirements for project or building commissioning as applicable, including review and approval of commissioning plans and qualifications of commissioning agents and/or service providers.
M&V	Describe post-installation M&V requirements and the role of M&V in project verification and incentive payment release.
Contractor certification	Describe certification requirements for contractors providing project construction and quality control services.
Minimum experience	In addition to certifications, any minimum experience requirements for contractors should be listed.
Training	List requirements for ongoing training.
PA notification requirements	Protocols for informing a PA representative of issues with project quality should be described.

Consultant QC Procedures

Issue	Criteria
Reporting requirements	Minimum requirements for consultant reports should be described.
Report review and approval	The report review procedures and affiliations and qualifications of report reviewers should be described.
Evaluation criteria	Evaluation criteria for consultant QC reviews should be listed.
Sampling requirements	Sampling procedures for consultant QC reviews should be described.
Consultant certifications	Certification requirements for consultants should be listed.
Consultant skills and experience	Beyond basic certification requirements, a description of the skill and experience requirements for consultants should be listed.
PA notification requirements	Protocols for informing a PA representative of issues with consultant services quality should be described.

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010

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APPENDIX A

BUILDING TYPES

The sections that follow provides savings data by building type. A description and additional details of each building type is shown in the table below and the sections that follow.

Note: the building type classifications are defined primarily by activity, HVAC system type, and number of floors since the deemed parameters in the 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 ^{o}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

Building Type	*Description*
Single-family residential	Single-family detached residences
Small Office	Office occupancy in buildings 3 stories or less served by packaged HVAC systems; includes Medical offices
Small Retail	Single story retail with ceiling height of less than 25 feet; primarily non-food retail and storage areas served by packaged HVAC systems. Includes service businesses, post offices, Laundromats, and exercise facilities.
University	University campus buildings, including classroom, computer labs, biological and/or chemical labs, workshop space, dining and office. Conditioned by built-up HVAC systems
Warehouse	Primarily non-refrigerated storage space could include attached offices served by packaged HVAC system.

Note: for commercial buildings that cannot be reasonably associated with one the building types above, savings values for the "other" category should be used.

PROTOTYPICAL BUILDING DESCRIPTIONS

RESIDENTIAL BUILDING PROTOTYPES

Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[61] study, with adjustments made for local building practices and climate. Three separate models were created to represent general vintages of buildings:

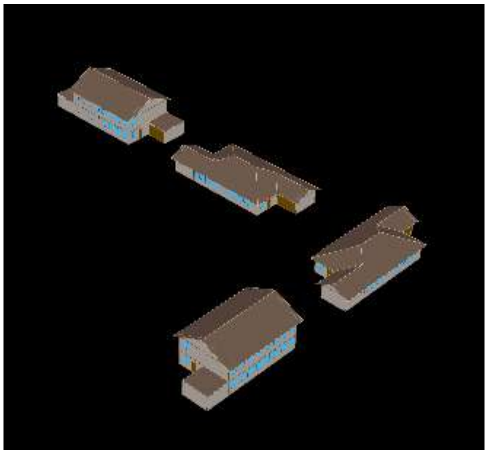
- Old, poorly insulated buildings constructed before 1979, before the NY State Energy Code went into effect. This vintage is referred to as the "old" vintage.
- Existing, average insulated buildings conforming to 1980s era building codes. This vintage is referred to as the "average" vintage, covering buildings constructed from 1979 to 2006.
- New construction conforming to the 2007 Energy Conservation 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.

SINGLE-FAMILY RESIDENTIAL PROTOTYPE

The single-family "model" in fact contains four separate residential buildings: 2 one-story and 2 two-story buildings. Each version of the 1 story and 2 story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these four buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact

[61] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

of energy efficiency measures. A sketch of the single-family residential prototype buildings is shown below.



The general characteristics of the single-family residential building prototype model are summarized below.

SINGLE-FAMILY RESIDENTIAL BUILDING PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Three vintages simulated – old poorly insulated buildings, existing average insulated buildings and new buildings
Conditioned floor area	1 story house: 1465 SF (not including basement) 2 story house: 2930 SF (not including basement)
Wall construction and R-value	Wood frame with siding, R-value varies by vintage
Roof construction and R-value	Wood frame with asphalt shingles, R-value varies by vintage
Glazing type	Single and double pane; properties vary by vintage
Lighting and appliance power density	0.51 W/SF average
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	Baseline SEER = 13
Thermostat set points	Heating: 70°F with setback to 67°F Cooling: 75°F with setup to 78°F
Duct location	Buildings without basement: attic Buildings with basement: basement
Duct surface area	Single story house: 390 SF supply, 72 SF return Two story house: 505 SF supply, 290 SF return
Duct insulation	Uninsulated
Duct leakage	20% of fan flow total leakage evenly split between supply and return.
Natural ventilation	Allowed during cooling season when cooling set point exceeded and outdoor temperature < 65°F. 3 air changes per hour

Wall, Floor and Ceiling Insulation Levels

The assumed values for wall and ceiling by vintage are shown below.

WALL INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated wall	Notes
Older, poorly insulated	4.8	No insulation in 2 by 4 wall; 3.5 in. air gap resistance only
Existing, average insulation	11	Fiberglass insulation in 2 by 4 wall per MEC 1980
New construction	19	Code

CEILING INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Older, poorly insulated	11	Minimal ceiling insulation
Existing, average insulation	19	Fiberglass insulation per MEC 1980
New construction	30 (NYC), 38 (all others)	Code

Windows

The glazing U-value and solar heat gain coefficient (SHGC) assumptions for the three vintages are shown below.

WINDOW PROPERTY ASSUMPTIONS BY VINTAGE

Vintage	U-value (BTU/hr-F-SF)	SHGC	Notes
Older, poorly insulated	0.93	0.87	Single pane clear
Existing, average insulation	0.87	0.77	Double pane clear
New construction	0.28	.49	Double low e

Infiltration

Infiltration rate assumptions were set by vintage as shown below.

INFILTRATION RATE ASSUMPTIONS BY VINTAGE

Vintage	Assumed infiltration rate	Notes
Older, poorly insulated	1 ACH	
Existing, average insulation	0.5 ACH	
New construction	0.35 ACH	Minimum without forced ventilation per ASHRAE Standard 66.

MULTI-FAMILY LOW-RISE

The low-rise prototype "model" in fact contains 2 separate buildings. Each version of the buildings is identical except for the orientation, which is shifted by 90 degrees. The selection of these 2 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures.

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

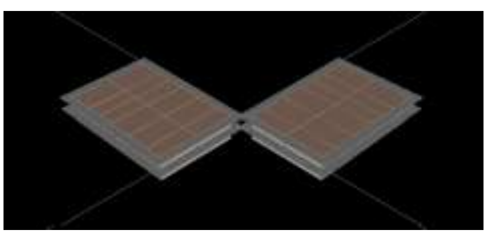
- Built prior to 1940, uninsulated masonry buildings. This vintage is referred to as "Pre-war uninsulated brick."

- Built prior to 1979 when the NYS Energy Code (known as the Energy Conservation Construction Code of New York State – ECCCNYS) went into effect, poorly insulated wood-frame buildings This vintage is referred to as "Prior to 1979"

- Built from 1979 through 2006, with insulation conforming to 1980s era building codes (1979 ECCCNYS.) This vintage is referred to as "From 1979 through 2006."

- Built from 2007 through the present, new construction with insulation conforming to the 2007 ECCCNYS for residential buildings and the New York City Energy Conservative Code (if applicable.) This vintage is referred to as "From 2007 through the present."

Each building vintage was run with 7 different HVAC system types to capture the range of HVAC systems common in low-rise multi-family buildings. A sketch of the low-rise prototype buildings is shown below.



The general characteristics of the residential building prototype model are summarized below.

MULTI-FAMILY LOW-RISE RESIDENTIAL BUILDING PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Four vintages simulated: Pre-war uninsulated brick; Prior to 1979 (wood frame); From 1979-2006; and From 2007 to present
Conditioned floor area	949 SF per unit; 6 units per floor, 2 floors per building, 11,388 SF total.
Wall construction and R-value	R-value and construction 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 set points	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 ductwork.
Duct surface area (for systems with ducts)	256 SF supply, 47 SF return per system
Duct insulation (for systems with ducts)	Uninsulated
Duct leakage (for systems with ducts)	20% of fan flow total leakage, evenly split between supply and return.
Natural ventilation	Allowed during cooling season when cooling set point exceeded and outdoor temperature < 65°F. 3 air changes per hour

Wall and Ceiling Insulation Levels

The assumed values for wall and ceiling by vintage are below.

WALL INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated wall	Notes
Pre-war uninsulated brick	4	Three 4" brick layers. No insulation. 2" air gap resistance only.
Prior to 1979	7	Wood frame with siding. No insulation in 2 by 4 wall; 3.5" air gap resistance only
From 1979 through 2006	11	Wood frame with siding. Fiberglass insulation in 2 by 4 wall per MEC 1980.
From 2007 through the present	19	Code

CEILING INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Pre-war uninsulated brick	2	No ceiling insulation
Prior to 1979	11	Minimal ceiling insulation
From 1979 through 2006	19	Fiberglass insulation per MEC 1980
From 2007 through the present	38	NYS Code for climate zones 4 & 5
	49	NYS Code for climate zone 6

THERMOSTATIC HEATING SET POINT ASSUMPTIONS BY VINTAGE

Vintage	Set point and setback (°F)	Notes
Pre-war uninsulated brick	73, 70	NYC
	70, 67	All others
Prior to 1979	70, 67	
From 1979 through 2006	70, 67	
From 2007 through the present	70, 67	

Windows

The glazing U-value and solar heat gain coefficient (SHGC) assumptions for the four vintages are shown below.

WINDOW PROPERTY ASSUMPTIONS BY VINTAGE

Vintage	U-value (BTU/hr-^{o}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

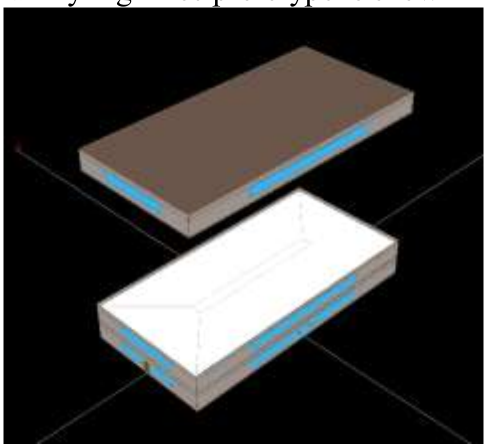
Infiltration rate assumptions were set by vintage as shown below.

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%
Thermostat set points	1. Heating: 70^{0}F with setback to 67^{0}F(other than NYC); 73^{0}F with setback to 700F (NYC only) 2. Cooling: 75°F with setup to 78°F

Wall, Floor Insulation Levels
The assumed values for wall and ceiling by vintage are shown below.

WALL INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated wall	Notes
Pre-war uninsulated brick	4	Same as low-rise
Prior to 1979	7	No insulation; air gap resistance only
From 1979 through 2006	11	Same as low-rise
From 2007 through the present	19	Code

ROOF INSULATION R-VALUE ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Pre-war uninsulated brick	2	Same as low-rise
Prior to 1979	11	Same as low-rise
From 1979 through 2006	19	Same as low-rise
From 2007 through the present	38	Code for climate zone 4 & 5
	49	Code for climate zone 6

THERMOSTATIC HEATING SET POINT ASSUMPTIONS BY VINTAGE

Vintage	Assumed R-value of insulated ceiling	Notes
Pre-war uninsulated brick	2	Same as low-rise
Prior to 1979	11	Same as low-rise
From 1979 through 2006	19	Same as low-rise
From 2007 through the present	38	Code for climate zone 4 & 5
	49	Code for climate zone 6

Windows

The glazing U-value and solar heat gain coefficient (SHGC) assumptions for the four vintages are shown below.

WINDOW PROPERTY ASSUMPTIONS BY VINTAGE

Vintage	U-value (BTU/hr-F-SF)	SHGC	Notes
Pre-war uninsulated brick	0.93	0.87	Single pane clear
Prior to 1979	0.93	0.87	Single pane clear
From 1979 through 2006	0.68	0.77	Double pane clear
From 2007 through the present	0.28	0.49	Double low E per code

Infiltration

Infiltration rate assumptions were set by vintage as shown below.

INFILTRATION RATE ASSUMPTIONS BY VINTAGE

Vintage	Assumed infiltration rate	Notes
Pre-war uninsulated brick	1 ACH	
Prior to 1979	1 ACH	Same as low-rise
From 1979 through 2006	0.5 ACH	Same as low-rise
From 2007 through the present	0.35 ACH	Minimum without forced ventilation per ASHRAE Standard 66.

COMMERCIAL BUILDING PROTOTYPES

Analysis used to develop parameters for the energy and demand savings calculations is based on DOE-2.2 simulations of a set of prototypical small and large buildings. The prototypical simulation models were derived from the commercial building prototypes used in the California Database for Energy Efficiency Resources (DEER)[62] study, with adjustments made for local building practices and climate.

The primary distinction between small and large buildings is the HVAC system type rather than a specific conditioned floor area criterion. Small buildings in this study utilize packaged rooftop HVAC systems or packaged terminal air conditioners (PTAC). Large buildings use built-up HVAC systems with chillers and boilers.

Note: for purposes of applying the building type specific results to buildings not included in the prototype list, use the "other" category within each applicable measure savings section.

Assembly

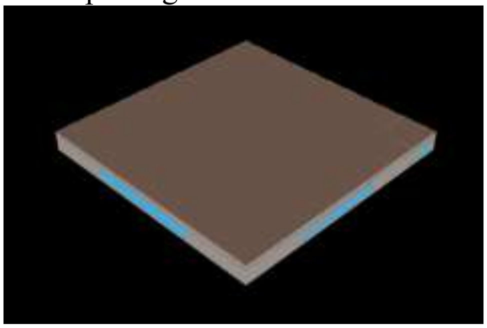
A prototypical building energy simulation model for an assembly building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

ASSEMBLY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 SF Office: 760 SF
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Auditorium: 3.4 W/SF Office: 2.2 W/SF
Plug load density	Auditorium: 1.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sun: 8am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 - 110 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

[62] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

A computer-generated sketch of the Assembly Building prototype is shown below.



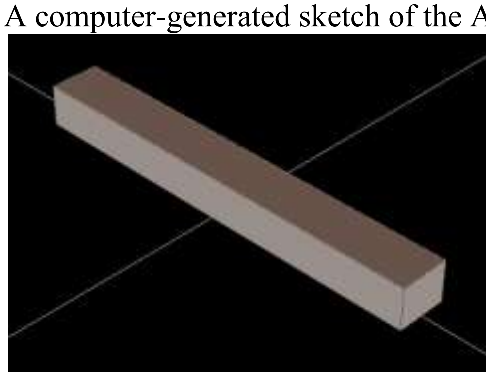
Auto Repair

A prototypical building energy simulation model for an auto repair building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

AUTO REPAIR PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	5150 square feet
Number of floors	1
Wall construction and R-value	Concrete block, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13,5
Glazing type	Double pane clear; SHGC = ,74 U-value = 0,72
Lighting power density	2.2 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sun: 9am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	280 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Auto Repair Building prototype is shown below.



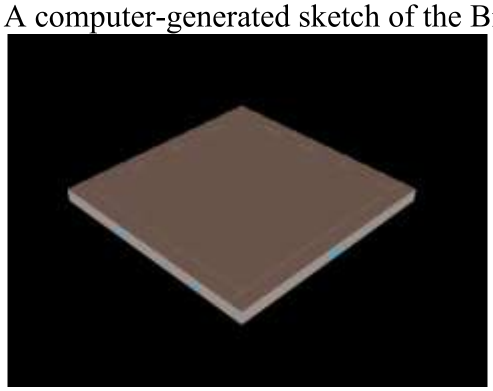
Big Box Retail

A prototypical building energy simulation model for a big box retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

BIG BOX RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 SF Storage: 11,870 SF Office: 4,683 SF Auto repair: 5,151 SF Kitchen: 1,459 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Storage: 0.88 W/SF Office: 2.2 W/SF Auto repair: 2.15 W/SF Kitchen: 4.3 W/SF
Plug load density	Sales: 1.15 W/SF Storage: 0.23 W/SF Office: 1.73 W/SF Auto repair: 1.15 W/SF Kitchen: 3.23 W/SF
Operating hours	Mon-Sun: 10am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 260 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Big Box Building prototype is shown below.



Community College

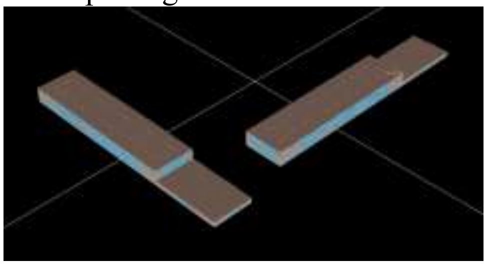
A prototypical building energy simulation model for a community college was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really two identical buildings oriented 90 degrees apart. The characteristics of the prototype are summarized below.

Community College Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 150,000 square feet each; oriented 90° from each other Classroom: 150,825 SF Computer room: 9,625 SF Dining area: 26,250 SF Kitchen: 5,625 SF Office: 70,175 SF Total: 300,000 SF
Number of floors	3
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Community College Building prototype is shown below.



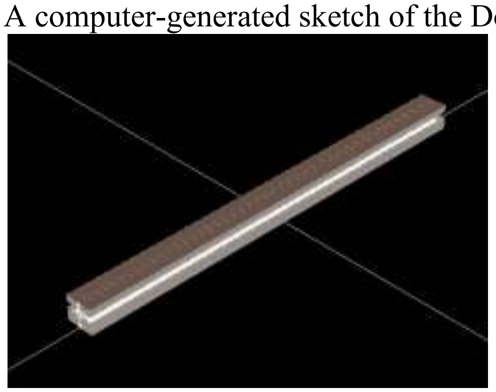
Dormitory

A prototypical building energy simulation model for a university dormitory was developed using the DOE-2.2 building energy simulation program. The dormitory building was extracted from the DEER university prototype and modeled separately. The model consists of two identical buildings oriented 90 degrees apart. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

DORMITORY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	170,000 square feet
Number of floors	4
Wall construction and R-value	CMU with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear; SHGC = 0.73 U-value = 0.72
Lighting power density	Rooms: 0.5 W/SF Corridors and common space: 0.8
Plug load density	Rooms: 0.6 W/SF Corridors and common space: 0.2
Operating hours	24/7 - 365
HVAC system type	Fan coils with centrifugal chiller and hot water boiler
HVAC system size	800 SF/ton
Thermostat set points	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

A computer-generated sketch of the Dormitory Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and the results are multiplied by 2 to represent the energy consumption of the 2 middle floors.

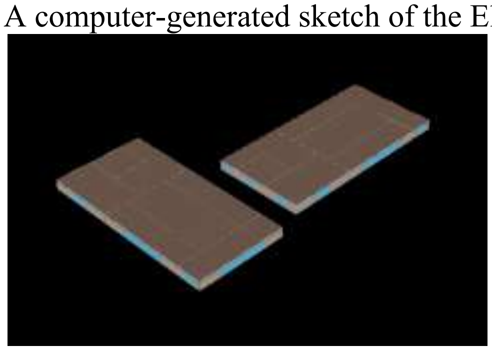
Elementary School

A prototypical building energy simulation model for an elementary school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of two identical buildings oriented in two different directions. The characteristics of the prototype are summarized below.

ELEMENTARY SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 15,750 SF Cafeteria: 3,750 SF Gymnasium: 3,750 SF Kitchen: 1,750 SF
Number of floors	1
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Classroom: 4.4 W/SF Cafeteria: 1.7 W/SF Gymnasium: 2.1 W/SF Kitchen: 4.3 W/SF
Plug load density	Classroom: 1.2 W/SF Cafeteria: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 4.2 W/SF
Operating hours	Mon-Fri: 8am – 6pm Sun: 8am – 4pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	160 - 180 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Elementary School Building prototype is shown below.



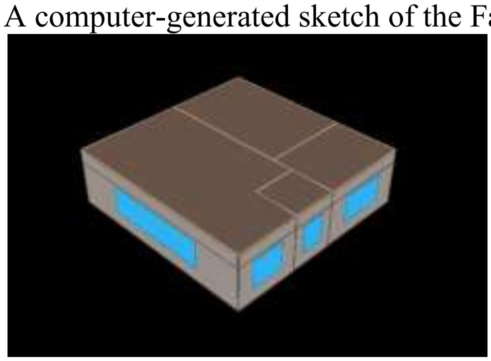
Fast Food Restaurant

A prototypical building energy simulation model for a fast food restaurant was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

FAST FOOD RESTAURANT PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square feet 1,000 SF dining 600 SF entry/lobby 300 SF kitchen 100 SF restroom
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	1.7 W/SF dining 2.5 W/SF entry/lobby 4.3 W/SF kitchen 1.0 W/SF restroom
Plug load density	0.6 W/SF dining 0.6 W/SF entry/lobby 4.3 W/SF kitchen 0.2 W/SF restroom
Operating hours	Mon-Sun: 6am – 11pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 – 120 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

A computer-generated sketch of the Fast Food Building prototype is shown below.



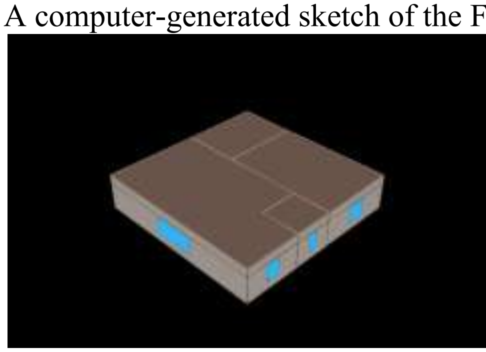
Full-Service Restaurant

A prototypical building energy simulation model for a full-service restaurant was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the full service restaurant prototype are summarized below.

FULL SERVICE RESTAURANT PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square foot dining area 600 square foot entry/reception area 1200 square foot kitchen 200 square foot restrooms
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Dining area: 1.7 W/SF Entry area: 2.5 W/SF Kitchen: 4.3 W/SF Restrooms: 1.0 W/SF
Plug load density	Dining area: 0.6 W/SF Entry area: 0.6 W/SF Kitchen: 3.1 W/SF Restrooms: 0.2 W/SF
Operating hours	9am – 12am
HVAC system type	Packaged single zone, no economizer
HVAC system size	140 – 160 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

A computer-generated sketch of the Full-Service Restaurant Building prototype is shown below.



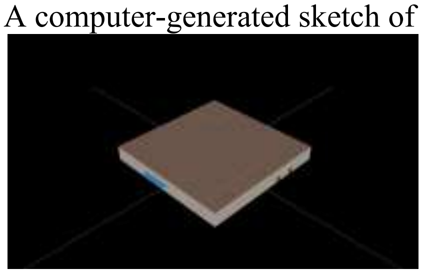
Grocery

A prototypical building energy simulation model for a grocery building was developed using the DOE-2.2R[63] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

GROCERY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	50,000 square feet Sales: 40,000 SF Office and employee lounge: 3,500 SF Dry storage: 2,860 SF 50 °F prep area: 1,268 SF 35 °F walk-in cooler: 1,560 SF - 5 °F walk-in freezer: 812 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Office: 2.2 W/SF Storage: 1.82 W/SF 50°F prep area: 4.3 W/SF 35°F walk-in cooler: 0.9 W/SF - 5°F walk-in freezer: 0.9 W/SF
Equipment power density	Sales: 1.15 W/SF Office: 1.73 W/SF Storage: 0.23 W/SF 50°F prep area: 0.23 W/SF + 36 kBTU/hr process load 35°F walk-in cooler: 0.23 W/SF + 17 kBTU/hr process load - 5°F walk-in freezer: 0.23 W/SF+ 29 kBTU/hr process load
Operating hours	Mon-Sun: 6am – 10pm
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	Low temperature (-20°F suction temp): 23 compressor ton Medium temperature (18°F suction temp): 45 compressor ton
Refrigeration condenser size	Low temperature: 535 kBTU/hr THR Medium temperature: 756 kBTU/hr THR
Thermostat set points	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

A computer-generated sketch of the Grocery Building prototype is shown below.



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

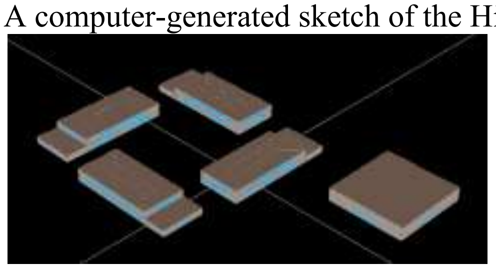
High School

A prototypical building energy simulation model for a high school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of four identical buildings oriented in four different directions, with a common gymnasium. The characteristics of the prototype are summarized below.

HIGH SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 88,200 SF Computer room: 3082 SF Dining area: 22,500 SF Gymnasium: 22.500 SF Kitchen: 10,500 SF Office: 3218 SF Total: 150,000 SF
Number of floors	2
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the High School Building prototype is shown below.



Hospital

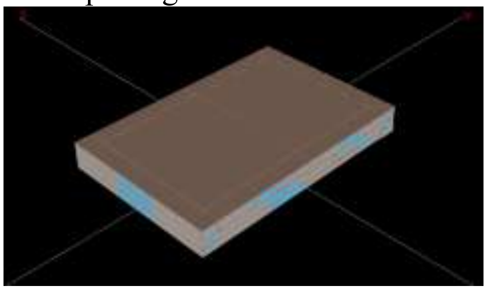
A prototypical building energy simulation model for a large hospital building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LARGE HOSPITAL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	250,000 square feet
Number of floors	3
Wall construction and R-value	Brick and CMU, R=7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Patient rooms: 2.3 W/SF Office: 2.2 W/SF Lab: 4.4 Dining: 1.7 Kitchen and food prep: 4.3
Plug load density	Patient rooms: 1.7 W/SF Office: 1.7 W/SF Lab: 1.7 Dining: 0.6 Kitchen and food prep: 4.6
Operating hours	24/7, 365
HVAC system types	Patient Rooms: 4 pipe fan coil Kitchen: Rooftop DX Remaining space; 1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Hospital Building prototype is shown below.



Hotel

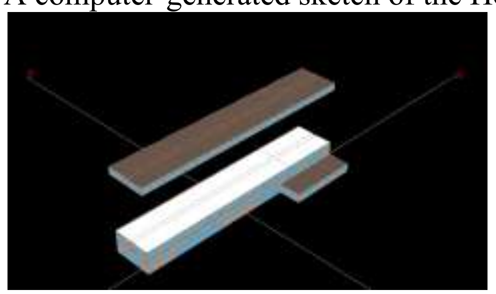
A prototypical building energy simulation model for a hotel building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

HOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	200,000 square feet total Bar, cocktail lounge – 800 SF Corridor – 20,100 SF Dining Area – 1,250 SF Guest rooms – 160,680 SF Kitchen – 750 SF Laundry – 4,100 SF Lobby – 8,220 Office – 4,100 SF
Number of floors	11
Wall construction and R-value	Block construction, R-7.5
Roof construction and R-value	Wood deck with built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Bar, cocktail lounge – 1.7 W/SF Corridor – 1.0 W/SF Dining Area – 1.7 W/SF Guest rooms – 0.6 W/SF Kitchen – 4.3 W/SF Laundry – 1.8 W/SF Lobby – 3.1 W/SF Office – 2.2 W/SF
Plug load density	Bar, cocktail lounge – 1.2 W/SF Corridor – 0.2 W/SF Dining Area – 0.6 W/SF Guest rooms – 0.6 W/SF Kitchen – 3.0 W/SF Laundry – 3.5 W/SF Lobby – 0.6 W/SF Office – 1.7 W/SF
Operating hours	Rooms: 60% occupied 40% unoccupied All others: 24 hr / day
HVAC system type	Central built-up system: All except corridors and rooms

Characteristic	Value
	1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer PTAC (Packaged Terminal Air Conditioner): Guest rooms PSZ: Corridors
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Minimum outdoor air fraction	Built up system 0.3; PSZ: 0.14; PTAC: 0.11 is typical.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Hotel Building prototype is shown below.



Large Office

A prototypical building energy simulation model for a large office building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

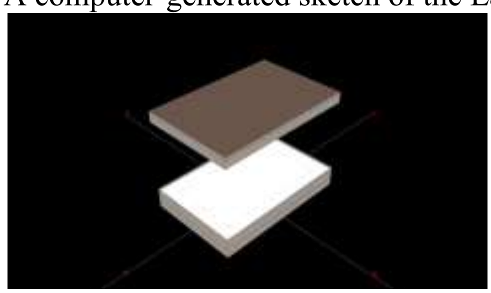
LARGE OFFICE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	350,000 square feet
Number of floors	10
Wall construction and R-value	Glass curtain wall, R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 W/SF Core offices: 1.45 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied

HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point
Thermostat set points	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 78 cooling, 67 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Office Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and the results are multiplied by 8 to represent the energy consumption of the eight middle floors.

Large Retail

A prototypical building energy simulation model for a large retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

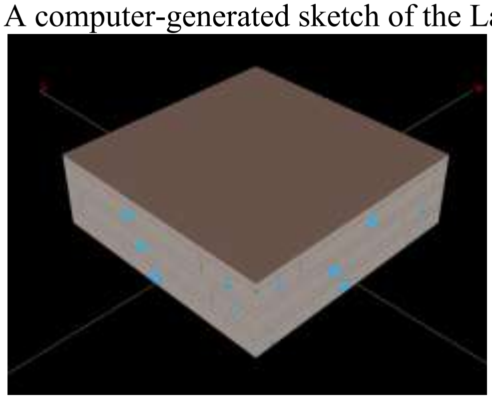
LARGE RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	**Existing (1970s) vintage**
Size	130,000 square feet Sales area: 96,000 SF Storage: 18,000 SF Office: 6,000 SF
Number of floors	3
Wall construction and R-value	Brick and CMU with R-7.5

Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; SHGC= 0.73 U-value = 0.72
Lighting power density	Sales area: 2.8 W/SF Storage: 0.8 W/SF Office: 1.8 W/SF
Plug load density	Sales area: 1.1 W/SF Storage: 0.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sat: 9am – 10pm Sun: 9am – 7pm
HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	340 SF/ton
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Retail Building prototype is shown below.



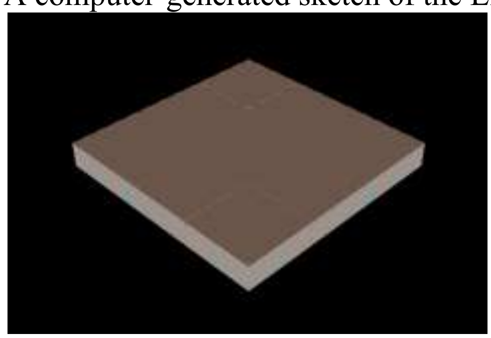
Light Industrial

A prototypical building energy simulation model for a light industrial building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

LIGHT INDUSTRIAL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total 80,000 SF factory 20,000 SF warehouse
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Factory – 2.1 W/SF Warehouse – 0.9 W/SF
Plug load density	Factory – 1.2 W/SF Warehouse – 0.2 W/SF
Operating hours	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	500 - 560 SF/ton depending on climate
Thermostat set points	Occupied hours: 78 cooling, 70 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the Light Industrial Building prototype is shown below.



Motel

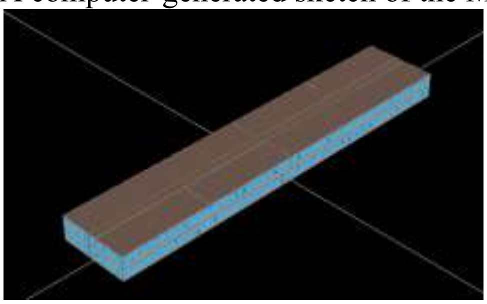
A prototypical building energy simulation model for a motel was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

MOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	30,000 square feet
Number of floors	2
Wall construction and R-value	Frame with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12

Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	0.6 W/SF
Plug load density	0.6 W/SF
Operating hours	24/7 - 365
HVAC system type	PTAC with electric heat
HVAC system size	540 SF/ton
Thermostat set points	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

A computer-generated sketch of the Motel Building prototype is shown below.



Refrigerated Warehouse

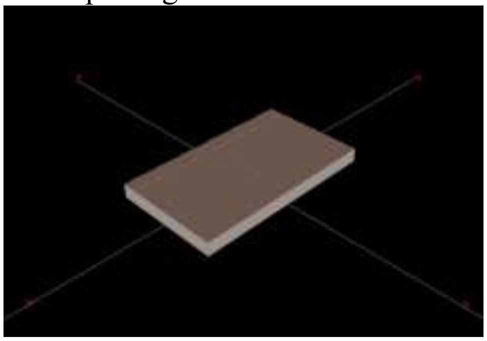
A prototypical building energy simulation model for a refrigerated warehouse building was developed using the DOE-2.2R[64] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

PROTOTYPICAL REFRIGERATED WAREHOUSE MODEL DESCRIPTION

Characteristic	Value
Vintage	New construction
Shape	Rectangular (400 ft by 230 ft)
Floor area	Freezer: 40,000 SF Cooler: 40,000 SF Shipping Dock: 12,000 SF Total: 92,000 SF
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

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

A computer-generated sketch of the Refrigerated Warehouse Building prototype is shown below.



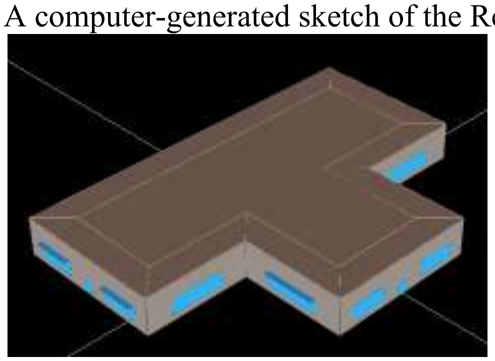
Religious

A prototypical building energy simulation model for a religious worship building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

RELIGIOUS WORSHIP PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	11,000 square feet
Number of floors	1
Wall construction and R-value	Brick with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	1.7 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sat: 12pm-6pm Sun: 9am – 7pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 70 heating Unoccupied hours: 82 cooling, 64 heating

A computer-generated sketch of the Religious Building prototype is shown below.



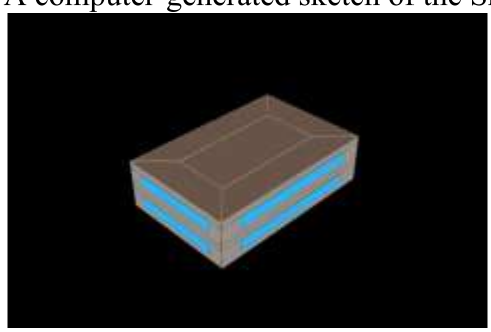
Small Office

A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small office prototype are summarized below.

SMALL OFFICE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	**Existing (1970s) vintage**
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Perimeter offices: 2.2 W/SF Core offices: 1.5 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 245 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Small Office Building prototype is shown below.



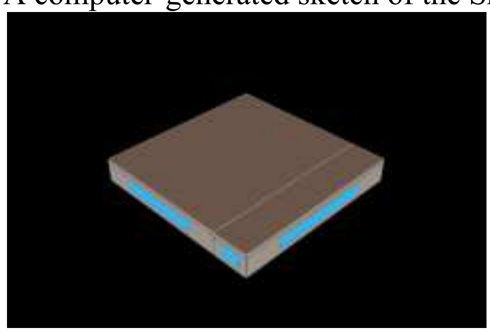
Small Retail

A prototypical building energy simulation model for a small retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small retail building prototype are summarized below.

SMALL RETAIL PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	6400 square foot sales area 1600 square foot storage area 8000 square feet total
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales area: 3.4 W/SF Storage area: 0.9 W/SF
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	10 – 10 Monday-Saturday 10 – 8 Sunday
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 – 250 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the Small Retail Building prototype is shown below.



University

A prototypical building energy simulation model for a university building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really four identical buildings oriented 90 degrees apart. The characteristics of the prototype are summarized below.

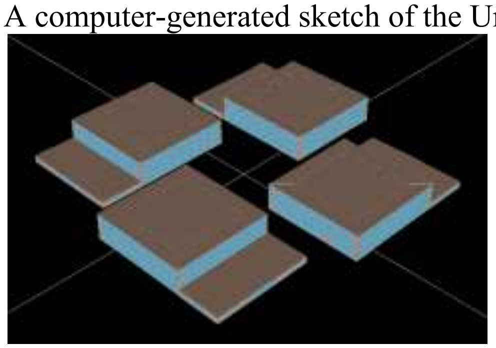
UNIVERSITY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 200,000 square feet each; oriented 90° from each other Classroom: 431,160 SF Computer room: 27,540 SF Dining area: 24,000 SF Kitchen: 10,500 SF Office: 226,800 SF Total: 800,000 SF
Number of floors	4
Wall construction and R-value	Insulated frame wall with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72

Characteristic	Value
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Office: 2.0 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Office: 1.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 10pm Sat: 8am – 7pm Sun: closed
HVAC system type	Combination PSZ and built-up with centrifugal chiller and hot water boiler.
HVAC system size	400 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 ^{o}F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 ^{o}F set point

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the University Building prototype is shown below.



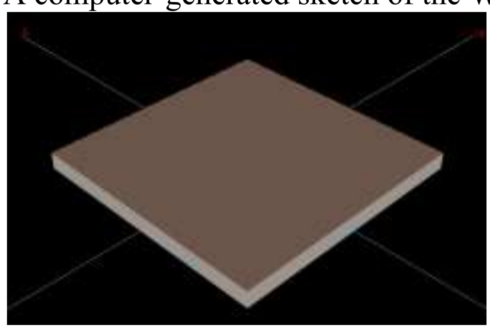
Warehouse

A prototypical building energy simulation model for a warehouse building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

WAREHOUSE PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	500,000
Number of floors	1
Wall construction and insulation R-value	Concrete block, R-5
Roof construction and insulation R-value	Wood deck with built-up roof, R-12
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	0.9 W/SF
Plug load density	0.2 W/SF
Operating hours	Mon-Fri: 7am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Thermostat set points	Occupied hours: 80 cooling, 68 heating Unoccupied hours: 85 cooling, 63 heating

A computer-generated sketch of the Warehouse Building prototype is shown below.



Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-1	7/31/2013
7-13-18	7/31/2013
7-13-19	7/31/2013
7-13-21	7/31/2013
3-14-1	3/17/2014

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APPENDIX B

HVAC WEIGHTING FACTORS

As described in the data sources and default value tables, it is permissible to use weighted average values across HVAC system types and building vintages when measure specific data are not available. Program administrators shall submit weighting factors used in their calculations for review and approval by the DPS. The weighting factors presented in this section may be used in lieu of program-specific weighting factors until such data are available.

Weighting factors developed for this section were taken from survey data compiled by the US Energy Information Agency (EIA), as part of the 2005 Residential Energy Consumption Survey (RECS) and the 2003 Commercial Building Energy Consumption Survey (CBECS). RECS survey data were collected specifically for New York state; CBECS data were collected for census division 2 (Middle Atlantic), which includes New York, New Jersey, and Pennsylvania.

SINGLE-FAMILY RESIDENTIAL BUILDING CALCULATIONS

The fractions of total building floor space for the Old and Average vintages are shown below. These data are compiled for building total (conditioned and unconditioned), heated and cooled floor space.

Vintage Weights for Single-family Detached Residential Buildings

	Total	Heated	Cooled
Old	0.441	0.420	0.358
Average	0.559	0.580	0.642

For example, approximately 64% of the cooled floor space is in buildings within the Average vintage, while 36% of the cooled floor space is in the Old vintage. Note, the RECS data did not provide information for new construction. Weighting calculations involving cooling savings should use the cooled floor space weights, while weighting calculations involving heating savings should use the heated floor space weights. Within each building vintage category, the weights by HVAC system type are shown below.

System Type Weights by Vintage for Single-family Detached Residential Buildings

System Type	Old	Average
AC with gas heat	0.474	0.616
Heat Pump	0.000	0.049
AC with electric heat	0.002	0.013
Electric heat only	0.004	0.017
Gas heat only	0.519	0.306
Room AC	0.629	0.371

MULTI-FAMILY RESIDENTIAL BUILDING CALCULATIONS

The fractions of total multi-family low-rise building floor space for the Old and Average vintage are shown below. These data are compiled for building total (conditioned and unconditioned), heated and cooled floor space. Low-rise buildings were identified as buildings with 2-4 units; or 1 or 2 story buildings with 5 or more units.

Vintage Weights for Low-rise Multi-family Residential Buildings

	Total	Heated	Cooled
Old	0.097	0.089	0.134
Average	0.903	0.911	0.866

The fractions of total multi-family high-rise building floor space for the Old and Average vintage are shown below. These data are compiled for building total (conditioned and unconditioned), heated and cooled floor space. High-rise buildings were identified as buildings with 3 or more stories.

Vintage Weights for High-rise Multi-family Residential Buildings

	Total	Heated	Cooled
Old	0.827	0.828	0.712
Average	0.173	0.172	0.288

Note, the RECS data did not provide information for new construction. Weighting calculations involving cooling savings should use the cooled floor space weights, while weighting calculations involving heating savings should use the heated floor space weights. For low-rise building calculations, weights by HVAC system type have been compiled. Within each building vintage category, the weights by HVAC system type are shown below.

HVAC System Type	Old	Average
AC with gas heat	0.542	0.350
Heat Pump	0.000	0.000
AC with electric heat	0.000	0.000
Electric heat only	0.006	0.012
Gas heat only	0.450	0.627
PTAC	0.003	0.012
PTHP	0.000	0.000

Note: The Tech Manual assumes a single HVAC system type for high-rise buildings, thus weighting across HVAC system types is not required.

COMMERCIAL BUILDING CALCULATIONS

Weighting Factors for Commercial Building Calculations

The 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:

System Type Weights for Built-Up HVAC Systems from CBECS

Building Type	AC with gas heat	Heat Pump	AC with electric heat	Electric heat only	Gas heat only
Assembly	0.63	0.08	0.12	0.03	0.14
Auto Repair	0.54	0.08	0.10	0.04	0.24

Big Box	0.66	0.07	0.18	0.02	0.07
Elementary School	0.68	0.11	0.11	0.01	0.08
Fast Food	0.67	0.09	0.18	0.01	0.06
Full Service	0.67	0.09	0.18	0.01	0.06
Grocery	0.66	0.07	0.18	0.02	0.07
Light Industrial	0.46	0.06	0.00	0.10	0.37
Motel	0.46	0.23	0.26	0.02	0.03
Religious	0.57	0.11	0.13	0.03	0.15
Small Office	0.69	0.10	0.19	0.00	0.02
Small Retail	0.66	0.07	0.18	0.02	0.07
Warehouse	0.46	0.06	0.00	0.10	0.37
Other	0.60	0.10	0.14	0.03	0.13

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

Savings estimates for large commercial buildings are developed for several HVAC system and chiller type combinations. The CBECS data were analyzed to develop system type weights for these building types. The weighting factors for each of the two HVAC system types constant volume reheat (CV) and variable air volume (VAV) are shown below.

System Type Weights for Built-Up HVAC Systems from CBECS

	Building					
System Type	**Hospital**	**Office**	**Education**	**Lodging**	**Retail**	**Other**
CV	0.16	0.14	0.31	1.00	0.16	0.35
VAV	0.84	0.86	0.69	0.00	0.84	0.65

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-22	7/31/2013
9-13-3	9/27/2013

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APPENDIX C

As a cross reference, the Effective Useful life (in hours) used for some lighting products, including LEDs, may be found in Appendix P which relies upon estimates established by the Design Lights Consortium and Energy Star.[65]

STANDARD FIXTURE WATTS [66]

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

[65] Some of the EULs of LED lighting products are based on the listing found in the Qualified Products List by the Design Light Consortium (DLC) at 35,000 or 50,000 hours, according to the appropriate Application Category as specified in the DLC"s *Product Qualification Criteria, Technical Requirement Table* version 2.0 or higher. The EUL of other LED products are based on the listing found in the *Energy Star Qualified Fixture List*, according to the appropriate luminaire classification as specified in the *Energy Star Program requirements for Luminaires*, version 1.2. The total hours are divided by estimated annual use, but capped at 15 years regardless (consistent with C&I redecoration and business type change patterns.)

[66] (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
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
CF38/2D	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Mag-STD	1	38	46
CF38/2D-L	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Electronic	1	38	36
CF42/1-L	CF42W	Compact Fluorescent, (1) 42W lamp	Electronic	1	42	48
CF42/2-L	CF42W	Compact Fluorescent, (2) 42W lamp	Electronic	2	42	100
CF42/3-L	CF42W	Compact Fluorescent, (3) 42W lamp	Electronic	3	42	141
CF42/4-L	CF42W	Compact Fluorescent, (4) 42W lamp	Electronic	4	42	188
CF42/6-L	CF42W	Compact Fluorescent, (6) 42W lamp	Electronic	6	42	282
CF42/8-L	CF42W	Compact Fluorescent, (8) 42W lamp	Electronic	8	42	376
CFQ10/1	CFQ10W	Compact Fluorescent, quad, (1) 10W lamp	Mag-STD	1	10	15
CFQ13/1	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp	Mag-STD	1	13	17
CFQ13/1-L	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp, BF=1.05	Electronic	1	13	15
CFQ13/2	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp	Mag-STD	2	13	31
CFQ13/2-L	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp, BF=1.0	Electronic	2	13	28
CFQ13/3	CFQ13W	Compact Fluorescent, quad, (3) 13W lamp	Mag-STD	3	13	48
CFQ15/1	CFQ15W	Compact Fluorescent, quad, (1) 15W lamp	Mag-STD	1	15	20
CFQ17/1	CFQ17W	Compact Fluorescent, quad, (1) 17W lamp	Mag-STD	1	17	24
CFQ17/2	CFQ17W	Compact Fluorescent, quad, (2) 17W lamp	Mag-STD	2	17	48
CFQ18/1	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp	Mag-STD	1	18	26
CFQ18/1-L	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp, BF=1.0	Electronic	1	18	20
CFQ18/2	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp	Mag-STD	2	18	45

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFQ18/2-L	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp, BF=1.0	Electronic	2	18	38
CFQ18/4	CFQ18W	Compact Fluorescent, quad, (4) 18W lamp	Mag-STD	2	18	90
CFQ20/1	CFQ20W	Compact Fluorescent, quad, (1) 20W lamp	Mag-STD	1	20	23
CFQ20/2	CFQ20W	Compact Fluorescent, quad, (2) 20W lamp	Mag-STD	2	20	46
CFQ22/1	CFQ22W	Compact Fluorescent, quad, (1) 22W lamp	Mag-STD	1	22	24
CFQ22/2	CFQ22W	Compact Fluorescent, quad, (2) 22W lamp	Mag-STD	2	22	48
CFQ22/3	CFQ22W	Compact Fluorescent, quad, (3) 22W lamp	Mag-STD	3	22	72
CFQ25/1	CFQ25W	Compact Fluorescent, quad, (1) 25W lamp	Mag-STD	1	25	33
CFQ25/2	CFQ25W	Compact Fluorescent, quad, (2) 25W lamp	Mag-STD	2	25	66
CFQ26/1	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp	Mag-STD	1	26	33
CFQ26/1-L	CFQ26W	Compact Fluorescent, quad, (1) 26W lamp, BF=0.95	Electronic	1	26	27
CFQ26/2	CFQ26W	Compact Fluorescent, quad, (2) 26W lamp	Mag-STD	2	26	66
CFQ26/2-L	CFQ26W	Compact Fluorescent, quad, (2) 26W lamp, BF=0.95	Electronic	2	26	50
CFQ26/3	CFQ26W	Compact Fluorescent, quad, (3) 26W lamp	Mag-STD	3	26	99
CFQ26/6-L	CFQ26W	Compact Fluorescent, quad, (6) 26W lamp, BF=0.95	Electronic	6	26	150
CFQ28/1	CFQ28W	Compact Fluorescent, quad, (1) 28W lamp	Mag-STD	1	28	33
CFQ9/1	CFQ9W	Compact Fluorescent, quad, (1) 9W lamp	Mag-STD	1	9	14
CFQ9/2	CFQ9W	Compact Fluorescent, quad, (2) 9W lamp	Mag-STD	2	9	23
CFS7/1	CFS7W	Compact Fluorescent, spiral, (1) 7W lamp	Electronic	1	7	7
CFS9/1	CFS9W	Compact Fluorescent, spiral, (1) 9W lamp	Electronic	1	9	9
CFS11/1	CFS11W	Compact Fluorescent, spiral, (1) 11W lamp	Electronic	1	11	11
CFS15/1	CFS15W	Compact Fluorescent, spiral, (1) 15W lamp	Electronic	1	15	15
CFS20/1	CFS20W	Compact Fluorescent, spiral, (1) 20W lamp	Electronic	1	20	20
CFS23/1	CFS23W	Compact Fluorescent, spiral, (1) 23W lamp	Electronic	1	23	23
CFS27/1	CFS27W	Compact Fluorescent, spiral, (1) 27W lamp	Electronic	1	27	27
CFT13/1	CFT13W	Compact Fluorescent, twin, (1) 13W lamp	Mag-STD	1	13	17

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFT13/2	CFT13W	Compact Fluorescent, twin, (2) 13W lamp	Mag-STD	2	13	31
CFT13/3	CFT13W	Compact Fluorescent, twin, (3) 13 W lamp	Mag-STD	3	13	48
CFT18/1	CFT18W	Compact Fluorescent, long twin., (1) 18W lamp	Mag-STD	1	18	24
CFT22/1	CFT22W	Compact Fluorescent, twin, (1) 22W lamp	Mag-STD	1	22	27
CFT22/2	CFT22W	Compact Fluorescent, twin, (2) 22W lamp	Mag-STD	2	22	54
CFT22/4	CFT22W	Compact Fluorescent, twin, (4) 22W lamp	Mag-STD	4	22	108
CFT24/1	CFT24W	Compact Fluorescent, long twin, (1) 24W lamp	Mag-STD	1	24	32
CFT28/1	CFT28W	Compact Fluorescent, twin, (1) 28W lamp	Mag-STD	1	28	33
CFT28/2	CFT28W	Compact Fluorescent, twin, (2) 28W lamp	Mag-STD	2	28	66
CFT32/1-L	CFM32W	Compact Fluorescent, twin or multi, (1) 32W lamp	Electronic	1	32	34
CFT32/2-L	CFM32W	Compact Fluorescent, twin or multi, (2) 32W lamp	Electronic	2	32	62
CFT32/6-L	CFM32W	Compact Fluorescent, twin or multi, (2) 32W lamp	Electronic	6	32	186
CFT36/1	CFT36W	Compact Fluorescent, long twin, (1) 36W lamp	Mag-STD	1	36	51
CFT36/4-BX	CFT36W	Compact Fluorescent, Biax, (4) 36W lamp	Electronic	4	36	148
CFT36/6-BX	CFT36W	Compact Fluorescent, Biax, (6) 36W lamp	Electronic	6	36	212
CFT36/6-L	CFT36W	Compact Fluorescent, long Twin, (6) 36W lamp	Electronic	6	36	198
CFT36/6-L	CFT36W	Compact Fluorescent, long Twin, (6) 36W lamp/ High Ballast Factor	Electronic	6	36	210
CFT36/8-BX	CFT36W	Compact Fluorescent, Biax, (8) 36W lamp	Electronic	8	36	296
CFT36/8-L	CFT36W	Compact Fluorescent, long Twin, (8) 36W lamp	Electronic	8	36	270
CFT36/8-L	CFT36W	Compact Fluorescent, long Twin, (8) 36W lamp/ High Ballast Factor	Electronic	8	36	286
CFT36/9-BX	CFT36W	Compact Fluorescent, Biax, (9) 36W lamp	Electronic	9	36	318
CFT40/1	CFT40W	Compact Fluorescent, twin, (1) 40W lamp	Mag-STD	1	40	46
CFT40/12-BX	CFT40W	Compact Fluorescent, Biax, (12) 40W lamp	Electronic	12	40	408
CFT40/1-BX	CFT40W	Compact Fluorescent, Biax, (1) 40W lamp	Electronic	1	40	46
CFT40/1-L	CFT40W	Compact Fluorescent, long twin, (1) 40W lamp	Electronic	1	40	43

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFT40/2	CFT40W	Compact Fluorescent, twin, (2) 40W lamp	Mag-STD	2	40	85
CFT40/2-BX	CFT40W	Compact Fluorescent, Biax, (2) 40W lamp	Electronic	2	40	72
CFT40/2-L	CFT40W	Compact Fluorescent, long twin, (2) 40W lamp	Electronic	2	40	72
CFT40/3	CFT40W	Compact Fluorescent, twin, (3) 40 W lamp	Mag-STD	3	40	133
CFT40/3-BX	CFT40W	Compact Fluorescent, Biax, (3) 40W lamp	Electronic	3	40	102
CFT40/3-L	CFT40W	Compact Fluorescent, long twin, (3) 40W lamp	Electronic	3	40	105
CFT40/4-BX	CFT40W	Compact Fluorescent, Biax, (4) 40W lamp	Electronic	4	40	144
CFT40/5-BX	CFT40W	Compact Fluorescent, Biax, (5) 40W lamp	Electronic	5	40	190
CFT40/6-BX	CFT40W	Compact Fluorescent, Biax, (6) 40W lamp	Electronic	6	40	204
CFT40/6-L	CFT40W	Compact Fluorescent, long Twin, (6) 40W lamp	Electronic	6	40	220
CFT40/6-L	CFT40W	Compact Fluorescent, long Twin, (6) 40W lamp/ High Ballast Factor	Electronic	6	40	233
CFT40/8-BX	CFT40W	Compact Fluorescent, Biax, (8) 40W lamp	Electronic	8	40	288
CFT40/8-L	CFT40W	Compact Fluorescent, long Twin, (8) 40W lamp	Electronic	8	40	300
CFT40/8-L	CFT40W	Compact Fluorescent, long Twin, (8) 40W lamp/ High Ballast Factor	Electronic	8	40	340
CFT40/9-BX	CFT40W	Compact Fluorescent, Biax, (9) 40W lamp	Electronic	9	40	306
CFT5/1	CFT5W	Compact Fluorescent, twin, (1) 5W lamp	Mag-STD	1	5	9
CFT5/2	CFT5W	Compact Fluorescent, twin, (2) 5W lamp	Mag-STD	2	5	18
CFT50/12-BX	CFT50W	Compact Fluorescent, Biax, (12) 50W lamp	Electronic	12	50	648
CFT50/1-BX	CFT50W	Compact Fluorescent, Biax, (1) 50W lamp	Electronic	1	50	54
CFT50/2-BX	CFT50W	Compact Fluorescent, Biax, (2) 50W lamp	Electronic	2	50	108
CFT50/3-BX	CFT50W	Compact Fluorescent, Biax, (3) 50W lamp	Electronic	3	50	162
CFT50/4-BX	CFT50W	Compact Fluorescent, Biax, (4) 50W lamp	Electronic	4	50	216
CFT50/5-BX	CFT50W	Compact Fluorescent, Biax, (5) 50W lamp	Electronic	5	50	270
CFT50/6-BX	CFT50W	Compact Fluorescent, Biax, (6) 50W lamp	Electronic	6	50	324
CFT50/8-BX	CFT50W	Compact Fluorescent, Biax, (8) 50W lamp	Electronic	8	50	432
CFT50/9-BX	CFT50W	Compact Fluorescent, Biax, (9) 50W lamp	Electronic	9	50	486
CFT55/12-BX	CFT55W	Compact Fluorescent, Biax, (12) 55W lamp	Electronic	12	55	672

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
CFT55/1-BX	CFT55W	Compact Fluorescent, Biax, (1) 55W lamp	Electronic	1	55	56
CFT55/2-BX	CFT55W	Compact Fluorescent, Biax, (2) 55W lamp	Electronic	2	55	112
CFT55/3-BX	CFT55W	Compact Fluorescent, Biax, (3) 55W lamp	Electronic	3	55	168
CFT55/4-BX	CFT55W	Compact Fluorescent, Biax, (4) 55W lamp	Electronic	4	55	224
CFT55/5-BX	CFT55W	Compact Fluorescent, Biax, (5) 55W lamp	Electronic	5	55	280
CFT55/6-BX	CFT55W	Compact Fluorescent, Biax, (6) 55W lamp	Electronic	6	55	336
CFT55/6-L	CFT55W	Compact Fluorescent, long Twin, (6) 55W lamp	Electronic	6	55	352
CFT55/6-L	CFT55W	Compact Fluorescent, long Twin, (6) 55W lamp/ High Ballast Factor	Electronic	6	55	373
CFT55/8-BX	CFT55W	Compact Fluorescent, Biax, (8) 55W lamp	Electronic	8	55	448
CFT55/8-L	CFT55W	Compact Fluorescent, long Twin, (8) 55W lamp	Electronic	8	55	468
CFT55/8-L	CFT55W	Compact Fluorescent, long Twin, (8) 55W lamp/ High Ballast Factor	Electronic	8	55	496
CFT55/9-BX	CFT55W	Compact Fluorescent, Biax, (9) 55W lamp	Electronic	9	55	504
CFT7/1	CFT7W	Compact Fluorescent, twin, (1) 7W lamp	Mag-STD	1	7	10
CFT7/2	CFT7W	Compact Fluorescent, twin, (2) 7W lamp	Mag-STD	2	7	21
CFT9/1	CFT9W	Compact Fluorescent, twin, (1) 9W lamp	Mag-STD	1	9	11
CFT9/2	CFT9W	Compact Fluorescent, twin, (2) 9W lamp	Mag-STD	2	9	23
CFT9/3	CFT9W	Compact Fluorescent, twin, (3) 9W lamp	Mag-STD	3	9	34
EXIT SIGN FIXTURES						
ECF5/1	CFT5W	EXIT Compact Fluorescent, (1) 5W lamp	Mag-STD	1	5	9
ECF5/2	CFT5W	EXIT Compact Fluorescent, (2) 5W lamp	Mag-STD	2	5	20
ECF7/1	CFT7W	EXIT Compact Fluorescent, (1) 7W lamp	Mag-STD	1	7	10
ECF7/2	CFT7W	EXIT Compact Fluorescent, (2) 7W lamp	Mag-STD	2	7	21
ECF8/1	F8T5	EXIT T5 Fluorescent, (1) 8W lamp	Mag-STD	1	8	12
ECF8/2	F8T5	EXIT T5 Fluorescent, (2) 8W lamp	Mag-STD	2	8	24
ECF9/1	CFT9W	EXIT Compact Fluorescent, (1) 9W lamp	Mag-STD	1	9	12
ECF9/2	CFT9W	EXIT Compact Fluorescent, (2) 9W lamp	Mag-STD	2	9	20
EI10/2	I10	EXIT Incandescent, (2) 10W lamp		2	10	20

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
EI15/1	I15	EXIT Incandescent, (1) 15W lamp		1	15	15
EI15/2	I15	EXIT Incandescent, (2) 15W lamp		2	15	30
EI20/1	I20	EXIT Incandescent, (1) 20W lamp		1	20	20
EI20/2	I20	EXIT Incandescent, (2) 20W lamp		2	20	40
EI25/1	I25	EXIT Incandescent, (1) 25W lamp		1	25	25
EI25/2	I25	EXIT Incandescent, (2) 25W lamp		2	25	50
EI34/1	I34	EXIT Incandescent, (1) 34W lamp		1	34	34
EI34/2	I34	EXIT Incandescent, (2) 34W lamp		2	34	68
EI40/1	I40	EXIT Incandescent, (1) 40W lamp		1	40	40
EI40/2	I40	EXIT Incandescent, (2) 40W lamp		2	40	80
EI5/1	I5	EXIT Incandescent, (1) 5W lamp		1	5	5
EI5/2	I5	EXIT Incandescent, (2) 5W lamp		2	5	10
EI50/2	I50	EXIT Incandescent, (2) 50W lamp		2	50	100
EI7.5/1	I7.5	EXIT Tungsten, (1) 7.5 W lamp		1	7.5	8
EI7.5/2	I7.5	EXIT Tungsten, (2) 7.5 W lamp		2	7.5	15
ELED0.5/1	LED0.5W	EXIT Light Emitting Diode, (1) 0.5W lamp, Single Sided		1	0.5	0.5
ELED0.5/2	LED0.5W	EXIT Light Emitting Diode, (2) 0.5W lamp, Dual Sided		2	0.5	1
ELED1.5/1	LED1.5W	EXIT Light Emitting Diode, (1) 1.5W lamp, Single Sided		1	1.5	1.5
ELED1.5/2	LED1.5W	EXIT Light Emitting Diode, (2) 1.5W lamp, Dual Sided		2	1.5	3
ELED10.5/1	LED10.5W	EXIT Light Emitting Diode, (1) 10.5W lamp, Single Sided		1	10.5	10.5
ELED10.5/2	LED10.5W	EXIT Light Emitting Diode, (2) 10.5W lamp, Dual Sided		2	10.5	21
ELED2/1	LED2W	EXIT Light Emitting Diode, (1) 2W lamp, Single Sided		1	2	2
ELED2/2	LED2W	EXIT Light Emitting Diode, (2) 2W lamp, Dual Sided		2	2	4

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
ELED3/1	LED3W	EXIT Light Emitting Diode, (1) 3W lamp, Single Sided		1	3	3
ELED3/2	LED3W	EXIT Light Emitting Diode, (2) 3W lamp, Dual Sided		2	3	6
ELED5/1	LED5W	EXIT Light Emitting Diode, (1) 5W lamp, Single Sided		1	5	5
ELED5/2	LED5W	EXIT Light Emitting Diode, (2) 5W lamp, Dual Sided		2	5	10
ELED8/1	LED8W	EXIT Light Emitting Diode, (1) 8W lamp, Single Sided		1	8	8
ELED8/2	LED8W	EXIT Light Emitting Diode, (2) 8W lamp, Dual Sided		2	8	16
LINEAR FLUORESCENT FIXTURES						
F1.51LS	F15T8	Fluorescent, (1) 18" T8 lamp	Mag-STD	1	15	19
F1.51SS	F15T12	Fluorescent, (1) 18" T12 lamp	Mag-STD	1	15	19
F1.52LS	F15T8	Fluorescent, (2) 18" T8 lamp	Mag-STD	2	15	36
F1.52SS	F15T12	Fluorescent, (2) 18", T12 lamp	Mag-STD	2	15	36
F21HS	F24T12/HO	Fluorescent, (1) 24", HO lamp	Mag-STD	1	35	62
F21ILL	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	20
F21ILL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	17	17
F21ILL/T2-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 2 Lamp Ballast	Electronic	1	17	15
F21ILL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	17	16
F21ILL/T3-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	17	14
F21ILL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	17	15

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F21ILL/T4-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	17	14
F21ILX-R	F17T8	Fluorescent, (1) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	1	17	15
F21ILX	F17T8	Fluorescent, (1) 24", T-8 lamp, HE Instant/Program Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	16
F21LL	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	17	16
F21LL/T2	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	17	16
F21LL/T3	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	17	17
F21LL/T4	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	17	17
F21LL-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	17	15
F21LS	F17T8	Fluorescent, (1) 24", T8 lamp, Standard Ballast	Mag-STD	1	17	24
F21GL	F24T5	Fluorescent, (1) 24", STD T5 lamp	Electronic	1	14	18
F21SE	F20T12	Fluorescent, (1) 24", STD lamp	Mag-ES	1	20	26
F21SS	F20T12	Fluorescent, (1) 24", STD lamp	Mag-STD	1	20	28
F21GHL	F24T5/HO	Fluorescent, (1) 24", STD HO T5 lamp	Electronic	1	24	29
F22SHS	F24T12/HO	Fluorescent, (2) 24", HO lamp	Mag-STD	2	35	90
F22GHL	F24T5/HO	Fluorescent, (2) 24", STD HO T5 lamp	Electronic	2	24	55
F22ILE	F17T8	Fluorescent, (2) 24", T-8 Instant Start lamp, Energy Saving Magnetic Ballast	Mag-ES	2	17	45
F22ILL	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	33
F22ILL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	31
F22ILL/T4-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	17	28

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F22ILL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	17	29
F22ILX-R	F17T8	Fluorescent, (2) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	2	17	27
F22ILX	F17T8	Fluorescent, (2) 24", T-8 lamp, HE Instant/Program Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	31
F22LL	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	31
F22LL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	34
F22LL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	17	28
F22GL	F24T5	Fluorescent, (2) 24", STD T5 lamp	Electronic	2	14	35
F22SE	F20T12	Fluorescent, (2) 24", STD lamp	Mag-ES	2	20	51
F22SS	F20T12	Fluorescent, (2) 24", STD lamp	Mag-STD	2	20	56
F23ILL	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	47
F23ILL-H	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	17	49
F23ILL-R	F17T8	Fluorescent, (3) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	17	43
F23ILX	F17T8	Fluorescent, (3) 24", T-8 lamp, HE Instant/Program Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	45
F23ILX-R	F17T8	Fluorescent, (3) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	3	17	40
F23LL	F17T8	Fluorescent, (3) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	17	52
F23LL-R	F17T8	Fluorescent, (3) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	17	41
F23SE	F20T12	Fluorescent, (3) 24", STD lamp	Mag-ES	3	20	77
F23SS	F20T12	Fluorescent, (3) 24", STD lamp	Mag-STD	3	20	84
F24ILL	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	61

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F24ILL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	17	55
F24ILX-R	F17T8	Fluorescent, (4) 24", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	4	17	53
F24LL	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	68
F24LL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	17	57
F24SE	F20T12	Fluorescent, (4) 24", STD lamp	Mag-ES	4	20	102
F24SS	F20T12	Fluorescent, (4) 24", STD lamp	Mag-STD	4	20	112
F26SE	F20T12	Fluorescent, (6) 24", STD lamp	Mag-ES	6	20	153
F26SS	F20T12	Fluorescent, (6) 24", STD lamp	Mag-STD	6	20	168
F31EE	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-ES	1	25	38
F31EE/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-ES	1	25	33
F31EL	F30T12/ES	Fluorescent, (1) 36", ES lamp	Electronic	1	25	26
F31ES	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-STD	1	25	42
F31ES/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-STD	1	25	37
F31ILL	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	26
F31ILL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31ILL/T2-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF: .96-1.1), Tandem 2 Lamp Ballast	Electronic	1	25	24
F31ILL/T2-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31ILL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	22
F31ILL/T3-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	25	22

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F31ILL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	22
F31ILL/T4-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	25	22
F31ILL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	25	28
F31ILL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	25	27
F31LL	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	24
F31LL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31LL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	24
F31LL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	22
F31LL-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	1	25	26
F31LL-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	25	23
F31ILX-R	F25T8	Fluorescent, (1) 36", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	1	25	21
F31SE/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-ES	1	30	37
F31GHL	F36T5/HO	Fluorescent, (1) 36", STD HO T5 lamp	Electronic	1	39	43
F31SHS	F36T12/HO	Fluorescent, (1) 36", HO lamp	Mag-STD	1	50	70
F31SL	F30T12	Fluorescent, (1) 36", STD lamp	Electronic	1	30	31
F31GL	F36T5	Fluorescent, (1) 36", STD T5 lamp	Electronic	1	21	27
F31SS	F30T12	Fluorescent, (1) 36", STD lamp	Mag-STD	1	30	46
F31SS/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-STD	1	30	41
F32EE	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-ES	2	25	66

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F32EL	F30T12/ES	Fluorescent, (2) 36", ES lamp	Electronic	2	25	50
F32ES	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-STD	2	25	73
F32ILL	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	46
F32ILL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	44
F32ILL/T4-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	25	43
F32ILL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	48
F32ILL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	25	46
F32ILX-R	F25T8	Fluorescent, (2) 36", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	2	25	39
F32LE	F25T8	Fluorescent, (2) 36", T-8 lamp	Mag-ES	2	25	65
F32LL	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	46
F32LL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	45
F32LL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	50
F32LL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	25	42
F32LL-V	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	25	70
F32SE	F30T12	Fluorescent, (2) 36", STD lamp	Mag-ES	2	30	74
F32GHL	F36T5/HO	Fluorescent, (1) 36", STD HO T5 lamp	Electronic	2	39	85
F32SHS	F36T12/HO	Fluorescent, (2) 36", HO, lamp	Mag-STD	2	50	114
F32SL	F30T12	Fluorescent, (2) 36", STD lamp	Electronic	2	30	58
F32GL	F36T5	Fluorescent, (1) 36", STD T5 lamp	Electronic	2	21	52
F32SS	F30T12	Fluorescent, (2) 36", STD lamp	Mag-STD	2	30	81
F33ES	F30T12/ES	Fluorescent, (3) 36", ES lamp	Mag-STD	3	25	115

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F33ILL	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	67
F33ILL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	66
F33LL	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	72
F33LL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	25	62
F33SE	F30T12	Fluorescent, (3) 36", STD lamp, (1) STD ballast and (1) ES ballast	Mag-ES	3	30	120
F33SS	F30T12	Fluorescent, (3) 36", STD lamp	Mag-STD	3	30	127
F34ILL	F25T8	Fluorescent, (4) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	25	87
F34ILL-R	F25T8	Fluorescent, (4) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	25	86
F34LL	F25T8	Fluorescent, (4) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	25	89
F34LL-R	F25T8	Fluorescent, (4) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	25	84
F34SE	F30T12	Fluorescent, (4) 36", STD lamp	Mag-ES	4	30	148
F34SL	F30T12	Fluorescent, (4) 36", STD lamp	Electronic	4	30	116
F34SS	F30T12	Fluorescent, (4) 36", STD lamp	Mag-STD	4	30	162
F36EE	F30T12/ES	Fluorescent, (6) 36", ES lamp	Mag-ES	6	25	198
F36ILL-R	F25T8	Fluorescent, (6) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85)	Electronic	6	25	134
F36SE	F30T12	Fluorescent, (6) 36", STD lamp	Mag-ES	6	30	238
F40EE/D1	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (1) hot ballast	Mag-ES	0	0	4
F40EE/D2	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (2) hot ballast	Mag-ES	0	0	8
F41EE	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-ES	1	34	43
F41EE/D2	F40T12/ES	Fluorescent, (1) 48", ES lamp, 2 ballast	Mag-ES	1	34	43
F41EE/T2	F40T12/ES	Fluorescent, (1) 48", ES lamp, tandem wired, 2-lamp ballast	Mag-ES	1	34	36

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41EHS	F48T12/HO/ES	Fluorescent, (1) 48", ES HO lamp	Mag-STD	1	55	80
F41EIS	F48T12/ES	Fluorescent, (1) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	1	30	51
F41EL	F40T12/ES	Fluorescent, (1) 48", T12 ES lamp, Electronic Ballast	Electronic	1	34	32
F41EL/T2	F40T12/ES	Fluorescent, (1) 48", T-12 ES lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	34	32
F41ES	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-STD	1	34	50
F41EVS	F48T12/VHO/ES	Fluorescent, (1) 48", VHO ES lamp	Mag-STD	1		123
F41IAL	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start Ballast	Electronic	1	25	25
F41IAL/T2-R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start, Tandem 2-Lamp Ballast, RLO (BF<0.85)	Electronic	1	25	19
F41IAL/T3-R	F25T12	Fluorescent, (1) 48", F25T12 lamp, Instant Start, Tandem 3-Lamp Ballast, RLO (BF<0.85)	Electronic	1	25	20
F41ILL	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	31
F41SILL	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	30	28
F41SILL/T2	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	30	27
F41SILL/T3	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	30	27
F41SILL/T4	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	30	26
F41SILL-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	30	25
F41SILL/T2-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	30	24
F41SILL/T3-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	30	24

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41SILL/T4-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	30	23
F41SILL-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	30	37
F41SILL/T2-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	30	36
F41SILL/T3-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	30	36
F41SSILL	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	28	26
F41SSILL/T2	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	28	25
F41SSILL/T3	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	28	25
F41SSILL/T4	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	28	24
F41SSILL-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	28	23
F41SSILL/T2-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	28	22
F41SSILL/T3-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	28	22
F41SSILL/T4-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	28	21
F41SSILL-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	28	33
F41SSILL/T2-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	28	32
F41SSILL/T3-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	28	32

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41ILL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	30
F41ILL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	32	33
F41ILL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	26
F41ILL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	32	30
F41ILL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	32	31
F41ILL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	32	26
F41ILL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	32	28
F41ILL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	32	26
F41ILL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	36
F41ILX-H	F32T8	Fluorescent, (1) 48", T-8 lamp, HE Instant/Program Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	35
F41ILX-R	F32T8	Fluorescent, (1) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	1	32	25
F41LE	F32T8	Fluorescent, (1) 48", T-8 lamp	Mag-ES	1	32	35
F41LL	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	32
F41LL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	30
F41LL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	32	39

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41LL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	27
F41LL/T3	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	32	31
F41LL/T3-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	32	33
F41LL/T3-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	32	25
F41LL/T4	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	32	30
F41LL/T4-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	32	26
F41LL-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	1	32	39
F41LL-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	32	27
F41SE	F40T12	Fluorescent, (1) 48", STD lamp	Mag-ES	1	40	50
F41GHL	F48T5/HO	Fluorescent, (1) 48", STD HO T5 lamp	Electronic	1	54	59
F41SHS	F48T12/HO	Fluorescent, (1) 48", STD HO lamp	Mag-STD	1	60	85
F41SIL	F48T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast	Electronic	1	39	46
F41SIL/T2	F48T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast, tandem wired	Electronic	1	39	37
F41SIS	F48T12	Fluorescent, (1) 48", STD IS lamp	Mag-STD	1	39	60
F41SIS/T2	F48T12	Fluorescent, (1) 48", STD IS lamp, tandem to 2-lamp ballast	Mag-STD	1	39	52
F41GL	F48T5	Fluorescent, (1) 48", STD T5 lamp	Electronic	1	28	32
F41SL/T2	F40T12	Fluorescent, (1) 48", T-12 STD lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	40	36
F41SS	F40T12	Fluorescent, (1) 48", STD lamp	Mag-STD	1	40	57
F41SVS	F48T12/VHO	Fluorescent, (1) 48", STD VHO lamp	Mag-STD	1	110	135

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41TS	F40T10	Fluorescent, (1) 48", T-10 lamp	Mag-STD	1	40	51
F42EE	F40T12/ES	Fluorescent, (2) 48", ES lamp	Mag-ES	2	34	72
F42EE/D2	F40T12/ES	Fluorescent, (2) 48", ES lamp, 2 Ballasts (delamped)	Mag-ES	2	34	76
F42EHS	F48T12/HO/ES	Fluorescent, (2) 42", HO lamp (3.5' lamp)	Mag-STD	2	55	135
F42EIS	F48T12/ES	Fluorescent, (2) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	2	30	82
F42EL	F40T12/ES	Fluorescent, (2) 48", T12 ES lamps, Electronic Ballast	Electronic	2	34	60
F42ES	F40T12/ES	Fluorescent, (2) 48", ES lamp	Mag-STD	2	34	80
F42EVS	F48T12/VHO/ES	Fluorescent, (2) 48", VHO ES lamp	Mag-STD	2		210
F42IAL/T4-R	F25T12	Fluorescent, (2) 48", F25T12 lamp, Instant Start, Tandem 4-Lamp Ballast, RLO (BF<0.85)	Electronic	2	25	40
F42IAL-R	F25T12	Fluorescent, (2) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	25	39
F42ILL	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	59
F42SILL	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	30	53
F41SILL/T4	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	30	52
F42SILL-R	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	30	47
F41SILL/T4-R	F30T8	Fluorescent, (2) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	30	46
F42SILL-H	F30T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-2.2)	Electronic	2	30	72
F42SSILL	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	28	48
F41SSILL/T4	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	28	47
F42SSILL-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	28	45

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F41SSILL/T4-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	28	44
F42SSILL-H	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-2.2)	Electronic	2	28	67
F42ILL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	56
F42ILL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	51
F42ILL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	65
F42ILL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	32	52
F42ILL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	2	32	79
F42ILX-H	F32T8	Fluorescent, (2) 48", T-8 lamp, HE Instant/Program Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	63
F42ILX-R	F32T8	Fluorescent, (2) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	2	32	48
F42ILX-V	F32T8	Fluorescent, (2) 48", T-8 lamp, HE Instant/Program Start Ballast, VHLO (BF>1.1)	Electronic	2	32	74
F42LE	F32T8	Fluorescent, (2) 48", T-8 lamp	Mag-ES	2	32	71
F42LL	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	32	60
F42LL/T4	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	32	59
F42LL/T4-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	32	53
F42LL-H	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	32	70
F42LL-R	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	32	54
F42LL-V	F32T8	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	32	85
F42SE	F40T12	Fluorescent, (2) 48", STD lamp	Mag-ES	2	40	86

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F42GHL	F48T5/HO	Fluorescent, (2) 48", STD HO T5 lamp	Electronic	2	54	117
F42SHS	F48T12/HO	Fluorescent, (2) 48", STD HO lamp	Mag-STD	2	60	145
F42SIL	F48T12	Fluorescent, (2) 48", STD IS lamp, Electronic ballast	Electronic	2	39	74
F42SIS	F48T12	Fluorescent, (2) 48", STD IS lamp	Mag-STD	2	39	103
F42GL	F48T5	Fluorescent, (2) 48", STD T5 lamp	Electronic	2	28	63
F42SS	F40T12	Fluorescent, (2) 48", STD lamp	Mag-STD	2	40	94
F42SVS	F48T12/VHO	Fluorescent, (2) 48", STD VHO lamp	Mag-STD	2	110	242
F43EE	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-ES	3	34	115
F43EHS	F48T12/HO/ES	Fluorescent, (3) 48", ES HO lamp (3.5' lamp)	Mag-STD	3	55	215
F43EIS	F48T12/ES	Fluorescent, (3) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	3	30	133
F43EL	F40T12/ES	Fluorescent, (3) 48", T12 ES lamps, Electronic Ballast	Electronic	3	34	92
F43ES	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-STD	3	34	130
F43EVS	F48T12/VHO/ES	Fluorescent, (3) 48", VHO ES lamp	Mag-STD	3		333
F43IAL-R	F25T12	Fluorescent, (3) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	60
F43ILL	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	89
F43SILL	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	30	78
F43SILL-R	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	30	70
F43SILL-H	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-3.3)	Electronic	3	30	105
F43SSILL	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	28	72
F43SSILL-R	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	28	66
F43SSILL-H	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-3.3)	Electronic	3	28	98
F43ILL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	90

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F43ILL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	93
F43ILL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	32	78
F43ILL-V	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	3	32	112
F43ILX-H	F32T8	Fluorescent, (3) 48", T-8 lamp, HE Instant/Program Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	90
F43ILX-R	F32T8	Fluorescent, (3) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	3	32	73
F43ILX-R/2	F32T8	Fluorescent, (3) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85), (2) ballast	Electronic	3	32	73
F43LE	F32T8	Fluorescent, (3) 48", T-8 lamp	Mag-ES	3	32	110
F43LL	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	93
F43LL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	92
F43LL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	98
F43LL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	32	76
F43SE	F40T12	Fluorescent, (3) 48", STD lamp	Mag-ES	3	40	136
F43GHL	F48T5/HO	Fluorescent, (3) 48", STD HO T5 lamp	Electronic	3	54	177
F43SHS	F48T12/HO	Fluorescent, (3) 48", STD HO lamp	Mag-STD	3	60	230
F43SIL	F40T12	Fluorescent, (3) 48", STD IS lamp, Electronic ballast	Electronic	3	39	120
F43SIS	F48T12	Fluorescent, (3) 48", STD IS lamp	Mag-STD	3	39	162
F43SS	F40T12	Fluorescent, (3) 48", STD lamp	Mag-STD	3	40	151
F43SVS	F48T12/VHO	Fluorescent, (3) 48", STD VHO lamp	Mag-STD	3	110	377
F44EE	F40T12/ES	Fluorescent, (4) 48", ES lamp	Mag-ES	4	34	144
F44EE/D4	F40T12/ES	Fluorescent, (4) 48", ES lamp, 4 Ballasts (delamped)	Mag-ES	4	34	152
F44EHS	F48T12/HO/ES	Fluorescent, (4) 48", ES HO lamp	Mag-STD	4	55	270

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F44EIS	F48T12/ES	Fluorescent, (4) 48" ES Instant Start lamp, Magnetic ballast	Mag-STD	4	30	164
F44EL	F40T12/ES	Fluorescent, (4) 48", T12 ES lamp, Electronic Ballast	Electronic	4	34	120
F44ES	F40T12/ES	Fluorescent, (4) 48", ES lamp	Mag-STD	4	34	160
F44EVS	F48T12/VHO/ES	Fluorescent, (4) 48", VHO ES lamp	Mag-STD	4		420
F44IAL-R	F25T12	Fluorescent, (4) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	25	80
F44ILL	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	112
F44SILL	F30T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	30	105
F44SILL-R	F30T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	30	91
F44SILL-H	F30T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-4.4)	Electronic	4	30	140
F44SSILL	F28T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	28	96
F44SSILL-R	F28T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	28	86
F44SSILL-H	F28T8	Fluorescent, (4) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-4.4)	Electronic	4	28	131
F44ILL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	118
F44ILL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	32	102
F44ILX-R	F32T8	Fluorescent, (4) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	4	32	96
F44ILX-R/2	F32T8	Fluorescent, (4) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85), (2) ballast	Electronic	4	32	96
F44LE	F32T8	Fluorescent, (4) 48", T-8 lamp	Mag-ES	4	32	142
F44LL	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	118
F44LL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	120

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F44LL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	32	105
F44SE	F40T12	Fluorescent, (4) 48", STD lamp	Mag-ES	4	40	172
F44GHL	F48T5/HO	Fluorescent, (4) 48", STD HO T5 lamp	Electronic	4	54	234
F44SHS	F48T12/HO	Fluorescent, (4) 48", STD HO lamp	Mag-STD	4	60	290
F44SIL	F48T12	Fluorescent, (4) 48", STD IS lamp, Electronic ballast	Electronic	4	39	148
F44SIS	F48T12	Fluorescent, (4) 48", STD IS lamp	Mag-STD	4	39	204
F44SS	F40T12	Fluorescent, (4) 48", STD lamp	Mag-STD	4	40	188
F44SVS	F48T12/VHO	Fluorescent, (4) 48", STD VHO lamp	Mag-STD	4	110	484
F45ILL	F32T8	Fluorescent, (5) 48", T-8 lamp, (1) 3-lamp IS ballast and (1) 2-lamp IS ballast, NLO (BF: .85-.95)	Electronic	5	32	148
F45GHL	F48T5/HO	Fluorescent, (5) 48", STD HO T5 lamp	Electronic	5	54	294
F46EE	F40T12/ES	Fluorescent, (6) 48", ES lamp	Mag-ES	6	34	216
F46EL	F40T12/ES	Fluorescent, (6) 48", ES lamp	Electronic	6	34	186
F46ES	F40T12/ES	Fluorescent, (6) 48", ES lamp	Mag-STD	6	34	236
F46ILL	F32T8	Fluorescent, (6) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	6	32	175
F46ILL-R	F32T8	Fluorescent, (6) 48", T-8 lamp, Instant Start Ballast, RLO (BF< .85)	Electronic	6	32	156
F46ILX-R	F32T8	Fluorescent, (6) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF< .85)	Electronic	6	32	146
F46LL	F32T8	Fluorescent, (6) 48", T-8 lamp, NLO (BF: .85-.95)	Electronic	6	32	182
F46GHL	F48T5/HO	Fluorescent, (6) 48", STD HO T5 lamp	Electronic	6	54	351
F46SE	F40T12	Fluorescent, (6) 48", STD lamp	Mag-ES	6	40	258
F46SS	F40T12	Fluorescent, (6) 48", STD lamp	Mag-STD	6	40	282
F48EE	F40T12/ES	Fluorescent, (8) 48", ES lamp	Mag-ES	8	34	288
F48ILL	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	8	32	224

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F48ILL-R	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	8	32	204
F48ILX-R	F32T8	Fluorescent, (8) 48", T-8 lamp, HE Instant/Program Start Ballast, RLO (BF<0.85)	Electronic	8	32	192
F48GHL	F48T5/HO	Fluorescent, (8) 48", STD HO T5 lamp	Electronic	8	54	468
F51ILHL	F60T12/HO	Fluorescent, (1) 60", T-8 HO lamp, Instant Start Ballast	Electronic	1	55	59
F51ILL	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	40	36
F51ILL/T2	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	40	36
F51ILL/T3	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	40	35
F51ILL/T4	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	40	34
F51ILL-R	F40T8	Fluorescent, (1) 60", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	40	43
F51SHE	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Mag-ES	1	75	88
F51SHL	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Electronic	1	75	69
F51GHL	F60T5/HO	Fluorescent, (1) 60", STD HO T5 lamp	Electronic	1	80	89
F51SHS	F60T12/HO	Fluorescent, (1) 60", STD HO lamp	Mag-STD	1	75	92
F51SL	F60T12	Fluorescent, (1) 60", STD lamp	Electronic	1	50	44
F51GL	F60T5	Fluorescent, (1) 60", STD T5 lamp	Electronic	1	35	39
F51SS	F60T12	Fluorescent, (1) 60", STD lamp	Mag-STD	1	50	63
F51SVS	F60T12/VHO	Fluorescent, (1) 60", VHO ES lamp	Mag-STD	1	135	165
F52ILHL	F60T12/HO	Fluorescent, (2) 60", T-8 HO lamp, Instant Start Ballast	Electronic	2	55	123
F52ILL	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	40	72

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F52ILL/T4	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	2	40	67
F52ILL-H	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	2	40	80
F52ILL-R	F40T8	Fluorescent, (2) 60", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	40	73
F52SHE	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Mag-ES	2	75	176
F52SHL	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Electronic	2	75	138
F52GHL	F60T5/HO	Fluorescent, (2) 60", STD HO T5 lamp	Electronic	2	49	106
F52SHS	F60T12/HO	Fluorescent, (2) 60", STD HO lamp	Mag-STD	2	75	168
F52SL	F60T12	Fluorescent, (2) 60", STD lamp	Electronic	2	50	88
F52GL	F60T5	Fluorescent, (2) 60", STD T5 lamp	Electronic	2	35	76
F52SS	F60T12	Fluorescent, (2) 60", STD lamp	Mag-STD	2	50	128
F52SVS	F60T12/VHO	Fluorescent, (2) 60", VHO ES lamp	Mag-STD	2	135	310
F53ILL	F40T8	Fluorescent, (3) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	40	106
F53ILL-H	F40T8	Fluorescent, (3) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	40	108
F54ILL	F40T8	Fluorescent, (4) 60", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	40	134
F54ILL-H	F40T8	Fluorescent, (4) 60", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	4	40	126
F61ISL	F72T12	Fluorescent, (1) 72", STD lamp, IS electronic ballast	Electronic	1	55	68
F61SE	F72T12	Fluorescent, (1) 72", STD lamp	Mag-ES	1	55	76
F61SHS	F72T12/HO	Fluorescent, (1) 72", STD HO lamp	Mag-STD	1	85	120
F61SS	F72T12	Fluorescent, (1) 72", STD lamp	Mag-STD	1	55	90
F61SVS	F72T12/VHO	Fluorescent, (1) 72", VHO lamp	Mag-STD	1	160	180
F62ILHL	F72T8	Fluorescent, (2) 72", T-8 HO lamp, Instant Start Ballast	Electronic	2	65	147
F62ISL	F72T12	Fluorescent, (2) 72", STD lamp, IS electronic ballast	Electronic	2	55	108

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F62SE	F72T12	Fluorescent, (2) 72", STD lamp	Mag-ES	2	55	122
F62SHE	F72T12/HO	Fluorescent, (2) 72", STD HO lamp	Mag-ES	2	85	194
F62SHS	F72T12/HO	Fluorescent, (2) 72", STD HO lamp	Mag-STD	2	85	220
F62SL	F72T12	Fluorescent, (2) 72", STD lamp	Electronic	2	55	108
F62SS	F72T12	Fluorescent, (2) 72", STD lamp	Mag-STD	2	55	145
F62SVS	F72T12/VHO	Fluorescent, (2) 72", VHO lamp	Mag-STD	2	160	330
F63ISL	F72T12	Fluorescent, (3) 72", STD lamp, IS electronic ballast	Electronic	3	55	176
F63SS	F72T12	Fluorescent, (3) 72", STD lamp	Mag-STD	3	55	202
F64ISL	F72T12	Fluorescent, (4) 72", STD lamp, IS electronic ballast	Electronic	4	55	216
F64SE	F72T12	Fluorescent, (4) 72", STD lamp	Mag-ES	4	55	230
F64SHE	F72T12/HO	Fluorescent, (4) 72", STD HO lamp	Mag-ES	4	85	388
F64SS	F72T12	Fluorescent, (4) 72", STD lamp	Mag-STD	4	55	244
F81EE/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, tandem to 2-lamp ballast	Mag-ES	1	60	62
F81EHL	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	Electronic	1	95	80
F81EHL/T2	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	95	85
F81EHS	F96T12/HO/ES	Fluorescent, (1) 96", ES HO lamp	Mag-STD	1	95	125
F81EL	F96T12/ES	Fluorescent, (1) 96", ES lamp	Electronic	1	60	60
F81EL/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	60	55
F81ES	F96T12/ES	Fluorescent, (1) 96", ES lamp	Mag-STD	1	60	83
F81ES/T2	F96T12/ES	Fluorescent, (1) 96", ES lamp, tandem to 2-lamp ballast	Mag-STD	1	60	64
F81EVS	F96T12/VHO/ES	Fluorescent, (1) 96", ES VHO lamp	Mag-STD	1	185	200
F81ILL	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	59	58

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F81ILL/T2	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	59	55
F81ILL/T2-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 2 Lamp Ballast	Electronic	1	59	49
F81ILL-H	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	59	68
F81ILL-R	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	59	57
F81ILL-V	F96T8	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, VHLO (BF>1.1)	Electronic	1	59	71
F81LHL	F96T8/HO	Fluorescent, (1) 96", T8 HO lamp	Electronic	1	86	85
F81LHL/T2	F96T8/HO	Fluorescent, (1) 96", T8 HO lamp, tandem wired to 2-lamp ballast	Electronic	1	86	80
F81SE	F96T12	Fluorescent, (1) 96", STD lamp	Mag-ES	1	75	91
F81EHS	F96T12/HO	Fluorescent, (1) 96", ES HO lamp	Mag-STD	1	95	125
F81SHE	F96T12/HO	Fluorescent, (1) 96", STD HO lamp	Mag-ES	1	110	132
F81SHL/T2	F96T12/HO	Fluorescent, (1) 96", STD HO lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	110	98
F81SHS	F96T12/HO	Fluorescent, (1) 96", STD HO lamp	Mag-STD	1	110	145
F81SL	F96T12	Fluorescent, (1) 96", STD lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	75	70
F81SL/T2	F96T12	Fluorescent, (1) 96", STD lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	75	67
F81SS	F96T12	Fluorescent, (1) 96", STD lamp	Mag-STD	1	75	100
F81SVS	F96T12/VHO	Fluorescent, (1) 96", STD VHO lamp	Mag-STD	1	215	230
F82EE	F96T12/ES	Fluorescent, (2) 96", ES lamp	Mag-ES	2	60	123
F82EHE	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Mag-ES	2	95	207
F82EHL	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Electronic	2	95	170
F82EHS	F96T12/HO/ES	Fluorescent, (2) 96", ES HO lamp	Mag-STD	2	95	227
F82EL	F96T12/ES	Fluorescent, (2) 96", ES lamp	Electronic	2	60	110

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F82ES	F96T12/ES	Fluorescent, (2) 96", ES lamp	Mag-STD	2	60	138
F82EVS	F96T12/VHO/ES	Fluorescent, (2) 96", ES VHO lamp	Mag-STD	2	185	390
F82ILL	F96T8	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	59	109
F82ILL-R	F96T8	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	59	98
F82LHL	F96T8/HO	Fluorescent, (2) 96", T8 HO lamp	Electronic	2	86	160
F82SE	F96T12	Fluorescent, (2) 96", STD lamp	Mag-ES	2	75	158
F82SHE	F96T12/HO	Fluorescent, (2) 96", STD HO lamp	Mag-ES	2	110	237
F82SHL	F96T12/HO	Fluorescent, (2) 96", STD HO lamp	Electronic	2	110	195
F82SHS	F96T12/HO	Fluorescent, (2) 96", STD HO lamp	Mag-STD	2	110	257
F82SL	F96T12	Fluorescent, (2) 96", STD lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	75	134
F82SS	F96T12	Fluorescent, (2) 96", STD lamp	Mag-STD	2	75	173
F82SVS	F96T12/VHO	Fluorescent, (2) 96", STD VHO lamp	Mag-STD	2	215	450
F83EE	F96T12/ES	Fluorescent, (3) 96", ES lamp	Mag-ES	3	60	210
F83EHE	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamp, (1) 2-lamp ES Ballast, (1) 1-lamp STD Ballast	Mag-ES/STD	3	95	319
F83EHS	F96T12/HO/ES	Fluorescent, (3) 96", ES HO lamp	Mag-STD	3	95	352
F83EL	F96T12/ES	Fluorescent, (3) 96", ES lamp	Electronic	3	60	179
F83ES	F96T12/ES	Fluorescent, (3) 96", ES lamp	Mag-STD	3	60	221
F83EVS	F96T12/VHO/ES	Fluorescent, (3) 96", ES VHO lamp	Mag-STD	3	185	590
F83ILL	F96T8	Fluorescent, (3) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	59	167
F83SHS	F96T12/HO	Fluorescent, (3) 96", STD HO lamp	Mag-STD	3	110	392
F83SS	F96T12	Fluorescent, (3) 96", STD lamp	Mag-STD	3	75	273
F83SVS	F96T12/VHO	Fluorescent, (3) 96", STD VHO lamp	Mag-STD	3	215	680
F84EE	F96T12/ES	Fluorescent, (4) 96", ES lamp	Mag-ES	4	60	246
F84EHE	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Mag-ES	4	95	414
F84EHL	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Electronic	4	95	340

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
F84EHS	F96T12/HO/ES	Fluorescent, (4) 96", ES HO lamp	Mag-STD	4	95	454
F84EL	F96T12/ES	Fluorescent, (4) 96", ES lamp	Electronic	4	60	220
F84ES	F96T12/ES	Fluorescent, (4) 96", ES lamp	Mag-STD	4	60	276
F84EVS	F96T12/VHO/ES	Fluorescent, (4) 96", ES VHO lamp	Mag-STD	4	185	780
F84ILL	F96T8	Fluorescent, (4) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	59	219
F84LHL	F96T8/HO	Fluorescent, (4) 96", T8 HO lamp	Electronic	4	86	320
F84SE	F96T12	Fluorescent, (4) 96", STD lamp	Mag-ES	4	75	316
F84SHE	F96T12/HO	Fluorescent, (4) 96", STD HO lamp	Mag-ES	4	110	474
F84SHL	F96T12/HO	Fluorescent, (3) 96", STD HO lamp	Electronic	4	110	390
F84SHS	F96T12/HO	Fluorescent, (4) 96", STD HO lamp	Mag-STD	4	110	514
F84SL	F96T12	Fluorescent, (4) 96", STD lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	75	268
F84SS	F96T12	Fluorescent, (4) 96", STD lamp	Mag-STD	4	75	346
F84SVS	F96T12/VHO	Fluorescent, (4) 96", STD VHO lamp	Mag-STD	4	215	900
F86EHS	F96T12/HO/ES	Fluorescent, (6) 96", ES HO lamp	Mag-STD	6	95	721
F86ILL	F96T8	Fluorescent, (6) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	6	59	328
CIRCLINE FLUORESCENT FIXTURES						
FC12/1	FC12T9	Fluorescent, (1) 12" circular lamp, RS ballast	Mag-STD	1	32	31
FC12/2	FC12T9	Fluorescent, (2) 12" circular lamp, RS ballast	Mag-STD	2	32	62
FC16/1	FC16T9	Fluorescent, (1) 16" circular lamp	Mag-STD	1	40	35
FC20	FC6T9	Fluorescent, Circlite, (1) 20W lamp, Preheat ballast	Mag-STD	1	20	20
FC22/1	FC8T9	Fluorescent, Circlite, (1) 22W lamp, preheat ballast	Mag-STD	1	22	20
FC22/32/1	FC22/32T9	Fluorescent, Circlite, (1) 22W/32W lamp, preheat ballast	Mag-STD	1	22/32	58
FC32/1	FC12T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	Mag-STD	1	32	40

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
FC32/40/1	FC32/40T9	Fluorescent, Circlite, (1) 32W/40W lamp, preheat ballast	Mag-STD	1	32/40	80
FC40/1	FC16T9	Fluorescent, Circline, (1) 32W lamp, preheat ballast	Mag-STD	1	32	42
FC44/1	FC44T9	Fluorescent, Circlite, (1) 44W lamp, preheat ballast	Mag-STD	1	44	46
FC6/1	FC6T9	Fluorescent, (1) 6" circular lamp, RS ballast	Mag-STD	1	20	25
FC8/1	FC8T9	Fluorescent, (1) 8" circular lamp, RS ballast	Mag-STD	1	22	26
FC8/2	FC8T9	Fluorescent, (2) 8" circular lamp, RS ballast	Mag-STD	2	22	52
U-TUBE FLUORESCENT FIXTURES						
FU1EE	FU40T12/ES	Fluorescent, (1) U-Tube, ES lamp	Mag-ES	1	34	43
FU1ILL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, Instant Start ballast	Electronic	1	32	31
FU1LL	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp	Electronic	1	32	32
FU1LL-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	1	31	27
FU1ILX-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, HE Instant/Program Start Ballast RLO (BF<0.85)	Electronic	1	31	25
FU2SS	FU40T12	Fluorescent, (2) U-Tube, STD lamp	Mag-STD	2	40	96
FU2SE	FU40T12	Fluorescent, (2) U-Tube, STD lamp	Mag-ES	2	40	85
FU2EE	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamp	Mag-ES	2	34	72
FU2ES	FU40T12/ES	Fluorescent, (2) U-Tube, ES lamp	Mag-STD	2	34	82
FU2ILL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start Ballast	Electronic	2	32	59
FU2ILL/T4	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start Ballast, tandem wired	Electronic	2	32	56
FU2ILL/T4-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start Ballast, RLO, tandem wired	Electronic	2	32	51
FU2ILL-H	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start HLO Ballast	Electronic	2	32	65
FU2ILL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Instant Start RLO Ballast	Electronic	2	32	52

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
FU2ILX-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, HE Instant/Program Start Ballast RLO (BF<0.85)	Electronic	2	31	48
FU2LL	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp	Electronic	2	32	60
FU2LL/T2	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, Tandem 4 lamp ballast	Electronic	2	32	59
FU2LL-R	FU31T8/6	Fluorescent, (2) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	54	31	54
FU3EE	FU40T12/ES	Fluorescent, (3) U-Tube, ES lamp	Mag-ES	3	35	115
FU3ILL	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamp, Instant Start Ballast	Electronic	3	32	89
FU3ILL-R	FU31T8/6	Fluorescent, (3) U-Tube, T-8 lamp, Instant Start RLO Ballast	Electronic	3	32	78
STANDARD INCANDESCENT FIXTURES						
I100/1	I100	Incandescent, (1) 100W lamp	N/A	1	100	100
I100/2	I100	Incandescent, (2) 100W lamp	N/A	2	100	200
I100/3	I100	Incandescent, (3) 100W lamp	N/A	3	100	300
I100/4	I100	Incandescent, (4) 100W lamp	N/A	4	100	400
I100/5	I100	Incandescent, (5) 100W lamp	N/A	5	100	500
I1000/1	I1000	Incandescent, (1) 1000W lamp	N/A	1	1000	1000
I100E/1	I100/ES	Incandescent, (1) 100W ES lamp	N/A	1	90	90
I100EL/1	I100/ES/LL	Incandescent, (1) 100W ES/LL lamp	N/A	1	90	90
I120/1	I120	Incandescent, (1) 120W lamp	N/A	1	120	120
I120/2	I120	Incandescent, (2) 120W lamp	N/A	2	120	240
I125/1	I125	Incandescent, (1) 125W lamp	N/A	1	125	125
I135/1	I135	Incandescent, (1) 135W lamp	N/A	1	135	135
I135/2	I135	Incandescent, (2) 135W lamp	N/A	2	135	270
I15/1	I15	Incandescent, (1) 15W lamp	N/A	1	15	15
I15/2	I15	Incandescent, (2) 15W lamp	N/A	2	15	30
I150/1	I150	Incandescent, (1) 150W lamp	N/A	1	150	150
I150/2	I150	Incandescent, (2) 150W lamp	N/A	2	150	300

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
I1500/1	I1500	Incandescent, (1) 1500W lamp	N/A	1	1500	1500
I150E/1	I150/ES	Incandescent, (1) 150W ES lamp	N/A	1	135	135
I150EL/1	I150/ES/LL	Incandescent, (1) 150W ES/LL lamp	N/A	1	135	135
I170/1	I170	Incandescent, (1) 170W lamp	N/A	1	170	170
I20/1	I20	Incandescent, (1) 20W lamp	N/A	1	20	20
I20/2	I20	Incandescent, (2) 20W lamp	N/A	2	20	40
I200/1	I200	Incandescent, (1) 200W lamp	N/A	1	200	200
I200/2	I200	Incandescent, (2) 200W lamp	N/A	2	200	400
I2000/1	I2000	Incandescent, (1) 2000W lamp	N/A	1	2000	2000
I200L/1	I200/LL	Incandescent, (1) 200W LL lamp	N/A	1	200	200
I25/1	I25	Incandescent, (1) 25W lamp	N/A	1	25	25
I25/2	I25	Incandescent, (2) 25W lamp	N/A	2	25	50
I25/4	I25	Incandescent, (4) 25W lamp	N/A	4	25	100
I250/1	I250	Incandescent, (1) 250W lamp	N/A	1	250	250
I300/1	I300	Incandescent, (1) 300W lamp	N/A	1	300	300
I34/1	I34	Incandescent, (1) 34W lamp	N/A	1	34	34
I34/2	I34	Incandescent, (2) 34W lamp	N/A	2	34	68
I36/1	I36	Incandescent, (1) 36W lamp	N/A	1	36	36
I40/1	I40	Incandescent, (1) 40W lamp	N/A	1	40	40
I40/2	I40	Incandescent, (2) 40W lamp	N/A	2	40	80
I400/1	I400	Incandescent, (1) 400W lamp	N/A	1	400	400
I40E/1	I40/ES	Incandescent, (1) 40W ES lamp	N/A	1	34	34
I40EL/1	I40/ES/LL	Incandescent, (1) 40W ES/LL lamp	N/A	1	34	34
I42/1	I42	Incandescent, (1) 42W lamp	N/A	1	42	42
I448/1	I448	Incandescent, (1) 448W lamp	N/A	1	448	448
I45/1	I45	Incandescent, (1) 45W lamp	N/A	1	45	45
I50/1	I50	Incandescent, (1) 50W lamp	N/A	1	50	50
I50/2	I50	Incandescent, (2) 50W lamp	N/A	2	50	100

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
I500/1	I500	Incandescent, (1) 500W lamp	N/A	1	500	500
I52/1	I52	Incandescent, (1) 52W lamp	N/A	1	52	52
I52/2	I52	Incandescent, (2) 52W lamp	N/A	2	52	104
I54/1	I54	Incandescent, (1) 54W lamp	N/A	1	54	54
I54/2	I54	Incandescent, (2) 54W lamp	N/A	2	54	108
I55/1	I55	Incandescent, (1) 55W lamp	N/A	1	55	55
I55/2	I55	Incandescent, (2) 55W lamp	N/A	2	55	110
I60/1	I60	Incandescent, (1) 60W lamp	N/A	1	60	60
I60/2	I60	Incandescent, (2) 60W lamp	N/A	2	60	120
I60/3	I60	Incandescent, (3) 60W lamp	N/A	3	60	180
I60/4	I60	Incandescent, (4) 60W lamp	N/A	4	60	240
I60/5	I60	Incandescent, (5) 60W lamp	N/A	5	60	300
I60E/1	I60/ES	Incandescent, (1) 60W ES lamp	N/A	1	52	52
I60EL/1	I60/ES/LL	Incandescent, (1) 60W ES/LL lamp	N/A	1	52	52
I65/1	I65	Incandescent, (1) 65W lamp	N/A	1	65	65
I65/2	I65	Incandescent, (2) 65W lamp	N/A	2	65	130
I67/1	I67	Incandescent, (1) 67W lamp	N/A	1	67	67
I67/2	I67	Incandescent, (2) 67W lamp	N/A	2	67	134
I67/3	I67	Incandescent, (3) 67W lamp	N/A	3	67	201
I69/1	I69	Incandescent, (1) 69W lamp	N/A	1	69	69
I7.5/1	I7.5	Tungsten exit light, (1) 7.5 W lamp, used in night light application	N/A	1	7.5	8
I7.5/2	I7.5	Tungsten exit light, (2) 7.5 W lamp, used in night light application	N/A	2	7.5	15
I72/1	I72	Incandescent, (1) 72W lamp	N/A	1	72	72
I75/1	I75	Incandescent, (1) 75W lamp	N/A	1	75	75
I75/2	I75	Incandescent, (2) 75W lamp	N/A	2	75	150
I75/3	I75	Incandescent, (3) 75W lamp	N/A	3	75	225
I75/4	I75	Incandescent, (4) 75W lamp	N/A	4	75	300

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
I750/1	I750	Incandescent, (1) 750W lamp	N/A	1	750	750
I75E/1	I75/ES	Incandescent, (1) 75W ES lamp	N/A	1	67	67
I75EL/1	I75/ES/LL	Incandescent, (1) 75W ES/LL lamp	N/A	1	67	67
I80/1	I80	Incandescent, (1) 80W lamp	N/A	1	80	80
I85/1	I85	Incandescent, (1) 85W lamp	N/A	1	85	85
I90/1	I90	Incandescent, (1) 90W lamp	N/A	1	90	90
I90/2	I90	Incandescent, (2) 90W lamp	N/A	2	90	180
I90/3	I90	Incandescent, (3) 90W lamp	N/A	3	90	270
I93/1	I93	Incandescent, (1) 93W lamp	N/A	1	93	93
I95/1	I95	Incandescent, (1) 95W lamp	N/A	1	95	95
I95/2	I95	Incandescent, (2) 95W lamp	N/A	2	95	190
HALOGEN INCANDESCENT FIXTURES						
H100/1	H100	Halogen Incandescent, (1) 100W lamp	N/A	1	100	100
H1000/1	H1000	Halogen Incandescent, (1) 1000W lamp	N/A	1	1000	1000
H1200/1	H1200	Halogen Incandescent, (1) 1200W lamp	N/A	1	1200	1200
H150/1	H150	Halogen Incandescent, (1) 150W lamp	N/A	1	150	150
H150/2	H150	Halogen Incandescent, (2) 150W lamp	N/A	2	150	300
H1500/1	H1500	Halogen Incandescent, (1) 1500W lamp	N/A	1	1500	1500
H200/1	H200	Halogen Incandescent, (1) 200W lamp	N/A	1	200	200
H250/1	H250	Halogen Incandescent, (1) 250W lamp	N/A	1	250	250
H300/1	H300	Halogen Incandescent, (1) 300W lamp	N/A	1	300	300
H35/1	H35	Halogen Incandescent, (1) 35W lamp	N/A	1	35	35
H350/1	H350	Halogen Incandescent, (1) 350W lamp	N/A	1	350	350
H40/1	H40	Halogen Incandescent, (1) 40W lamp	N/A	1	40	40
H400/1	H400	Halogen Incandescent, (1) 400W lamp	N/A	1	400	400
H42/1	H42	Halogen Incandescent, (1) 42W lamp	N/A	1	42	42
H425/1	H425	Halogen Incandescent, (1) 425W lamp	N/A	1	425	425
H45/1	H45	Halogen Incandescent, (1) 45W lamp	N/A	1	45	45

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
H45/2	H45	Halogen Incandescent, (2) 45W lamp	N/A	2	45	90
H50/1	H50	Halogen Incandescent, (1) 50W lamp	N/A	1	50	50
H50/2	H50	Halogen Incandescent, (2) 50W lamp	N/A	2	50	100
H500/1	H500	Halogen Incandescent, (1) 500W lamp	N/A	1	500	500
H52/1	H52	Halogen Incandescent, (1) 52W lamp	N/A	1	52	52
H55/1	H55	Halogen Incandescent, (1) 55W lamp	N/A	1	55	55
H55/2	H55	Halogen Incandescent, (2) 55W lamp	N/A	2	55	110
H60/1	H60	Halogen Incandescent, (1) 60W lamp	N/A	1	60	60
H72/1	H72	Halogen Incandescent, (1) 72W lamp	N/A	1	72	72
H75/1	H75	Halogen Incandescent, (1) 75W lamp	N/A	1	75	75
H75/2	H75	Halogen Incandescent, (2) 75W lamp	N/A	2	75	150
H750/1	H750	Halogen Incandescent, (1) 750W lamp	N/A	1	750	750
H90/1	H90	Halogen Incandescent, (1) 90W lamp	N/A	1	90	90
H90/2	H90	Halogen Incandescent, (2) 90W lamp	N/A	2	90	180
H900/1	H900	Halogen Incandescent, (1) 900W lamp	N/A	1	900	900
HLV20/1	H20/LV	Halogen Low Voltage Incandescent, (1) 20W lamp	N/A	1	20	30
HLV25/1	H25/LV	Halogen Low Voltage Incandescent, (1) 25W lamp	N/A	1	25	35
HLV35/1	H35/LV	Halogen Low Voltage Incandescent, (1) 35W lamp	N/A	1	35	45
HLV42/1	H42/LV	Halogen Low Voltage Incandescent, (1) 42W lamp	N/A	1	42	52
HLV50/1	H50/LV	Halogen Low Voltage Incandescent, (1) 50W lamp	N/A	1	50	60
HLV65/1	H65/LV	Halogen Low Voltage Incandescent, (1) 65W lamp	N/A	1	65	75
HLV75/1	H75/LV	Halogen Low Voltage Incandescent, (1) 75W lamp	N/A	1	75	85
QL INDUCTION FIXTURES						
QL55/1	QL55	QL Induction, (1) 55W lamp	Generator	1	55	55

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
QL85/1	QL85	QL Induction, (1) 85W lamp	Generator	1	85	85
QL165/1	QL165	QL Induction, (1) 165W lamp	Generator	1	165	165
HIGH PRESSURE SODIUM FIXTURES						
HPS100/1	HPS100	High Pressure Sodium, (1) 100W lamp	CWA	1	100	138
HPS1000/1	HPS1000	High Pressure Sodium, (1) 1000W lamp	CWA	1	1000	1100
HPS150/1	HPS150	High Pressure Sodium, (1) 150W lamp	CWA	1	150	188
HPS200/1	HPS200	High Pressure Sodium, (1) 200W lamp	CWA	1	200	250
HPS225/1	HPS225	High Pressure Sodium, (1) 225W lamp	CWA	1	225	275
HPS250/1	HPS250	High Pressure Sodium, (1) 250W lamp	CWA	1	250	295
HPS310/1	HPS310	High Pressure Sodium, (1) 310W lamp	CWA	1	310	365
HPS35/1	HPS35	High Pressure Sodium, (1) 35W lamp	CWA	1	35	46
HPS360/1	HPS360	High Pressure Sodium, (1) 360W lamp	CWA	1	360	414
HPS400/1	HPS400	High Pressure Sodium, (1) 400W lamp	CWA	1	400	465
HPS50/1	HPS50	High Pressure Sodium, (1) 50W lamp	CWA	1	50	66
HPS600/1	HPS600	High Pressure Sodium, (1) 600W lamp	CWA	1	600	675
HPS70/1	HPS70	High Pressure Sodium, (1) 70W lamp	CWA	1	70	95
HPS750/1	HPS750	High Pressure Sodium, (1) 750W lamp	CWA	1	750	835
METAL HALIDE FIXTURES						
MH100/1	MH100	Metal Halide, (1) 100W lamp	CWA	1	100	128
MH1000/1	MH1000	Metal Halide, (1) 1000W lamp	CWA	1	1000	1080
MH150/1	MH150	Metal Halide, (1) 150W lamp	CWA	1	150	190
MH1500/1	MH1500	Metal Halide, (1) 1500W lamp	CWA	1	1500	1610
MH175/1	MH175	Metal Halide, (1) 175W lamp	CWA	1	175	215
MH1800/1	MH1800	Metal Halide, (1) 1800W lamp	CWA	1	1800	1875
MH200/1	MH200	Metal Halide, (1) 200W lamp	CWA	1	200	232
MH250/1	MH250	Metal Halide, (1) 250W lamp	CWA	1	250	295
MH32/1	MH32	Metal Halide, (1) 32W lamp	CWA	1	32	43

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
MH300/1	MH300	Metal Halide, (1) 300W lamp	CWA	1	300	342
MH320/1	MH320	Metal Halide, (1) 320W lamp	CWA	1	320	365
MH350/1	MH350	Metal Halide, (1) 350W lamp	CWA	1	350	400
MH360/1	MH360	Metal Halide, (1) 360W lamp	CWA	1	360	430
MH400/1	MH400	Metal Halide, (1) 400W lamp	CWA	1	400	458
MH400/2	MH400	Metal Halide, (2) 400W lamp	CWA	2	400	916
MH450/1	MH450	Metal Halide, (1) 450W lamp	CWA	1	450	508
MH35/1	MH35	Metal Halide, (1) 35W lamp	CWA	1	35	44
MH50/1	MH50	Metal Halide, (1) 50W lamp	CWA	1	50	72
MH70/1	MH70	Metal Halide, (1) 70W lamp	CWA	1	70	95
MH750/1	MH750	Metal Halide, (1) 750W lamp	CWA	1	750	850
MHPS/LR/100/1	MHPS100	Metal Halide Pulse Start, (1) 100W lamp w/ Linear Reactor Ballast	LR	1	100	118
MHPS/LR/150/1	MHPS150	Metal Halide Pulse Start, (1) 150W lamp w/ Linear Reactor Ballast	LR	1	150	170
MHPS/LR/175/1	MHPS175	Metal Halide Pulse Start, (1) 175W lamp w/ Linear Reactor Ballast	LR	1	175	194
MHPS/LR/200/1	MHPS200	Metal Halide Pulse Start, (1) 200W lamp w/ Linear Reactor Ballast	LR	1	200	219
MHPS/LR/250/1	MHPS250	Metal Halide Pulse Start, (1) 250W lamp w/ Linear Reactor Ballast	LR	1	250	275
MHPS/LR/300/1	MHPS300	Metal Halide Pulse Start, (1) 300W lamp w/ Linear Reactor Ballast	LR	1	300	324
MHPS/LR/320/1	MHPS320	Metal Halide Pulse Start, (1) 320W lamp w/ Linear Reactor Ballast	LR	1	320	349
MHPS/LR/350/1	MHPS350	Metal Halide Pulse Start, (1) 350W lamp w/ Linear Reactor Ballast	LR	1	350	380
MHPS/LR/400/1	MHPS400	Metal Halide Pulse Start, (1) 400W lamp w/ Linear Reactor Ballast	LR	1	400	435
MHPS/LR/450/1	MHPS450	Metal Halide Pulse Start, (1) 450W lamp w/ Linear Reactor Ballast	LR	1	450	485
MHPS/LR/750/1	MHPS750	Metal Halide Pulse Start, (1) 750W lamp w/ Linear Reactor Ballast	LR	1	750	805

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
MHPS/SCWA/100/1	MHPS100	Metal Halide Pulse Start, (1) 100W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	100	128
MHPS/SCWA/1000/1	MHPS1000	Metal Halide Pulse Start, (1) 1000W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	1000	1080
MHPS/SCWA/150/1	MHPS150	Metal Halide Pulse Start, (1) 150W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	150	190
MHPS/SCWA/175/1	MHPS175	Metal Halide Pulse Start, (1) 175W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	175	208
MHPS/SCWA/200/1	MHPS200	Metal Halide Pulse Start, (1) 200W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	200	232
MHPS/SCWA/250/1	MHPS250	Metal Halide Pulse Start, (1) 250W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	250	288
MHPS/SCWA/300/1	MHPS300	Metal Halide Pulse Start, (1) 300W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	300	342
MHPS/SCWA/320/1	MHPS320	Metal Halide Pulse Start, (1) 320W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	320	368
MHPS/SCWA/350/1	MHPS350	Metal Halide Pulse Start, (1) 350W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	350	400
MHPS/SCWA/400/1	MHPS400	Metal Halide Pulse Start, (1) 400W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	400	450
MHPS/SCWA/450/1	MHPS450	Metal Halide Pulse Start, (1) 450W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	450	506
MHPS/SCWA/750/1	MHPS750	Metal Halide Pulse Start, (1) 750W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	750	815
MERCURY VAPOR FIXTURES						
MV100/1	MV100	Mercury Vapor, (1) 100W lamp	CWA	1	100	125
MV1000/1	MV1000	Mercury Vapor, (1) 1000W lamp	CWA	1	1000	1075
MV175/1	MV175	Mercury Vapor, (1) 175W lamp	CWA	1	175	205
MV250/1	MV250	Mercury Vapor, (1) 250W lamp	CWA	1	250	290
MV40/1	MV40	Mercury Vapor, (1) 40W lamp	CWA	1	40	50
MV400/1	MV400	Mercury Vapor, (1) 400W lamp	CWA	1	400	455
MV400/2	MV400	Mercury Vapor, (2) 400W lamp	CWA	2	400	910
MV50/1	MV50	Mercury Vapor, (1) 50W lamp	CWA	1	50	74

Fixture Code	Lamp Code	Description	Ballast	Lamp/Fixture	Watt / Lamp	Watt / Fixture
MV700/1	MV700	Mercury Vapor, (1) 700W lamp	CWA	1	700	780
MV75/1	MV75	Mercury Vapor, (1) 75W lamp	CWA	1	75	93

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-23	7/31/2013

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APPENDIX D

HVAC INTERACTIVE EFFECTS MULTIPLIERS

SINGLE-FAMILY RESIDENTIAL

	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.043	0.073	-0.026	-0.214	0.119	0.000	-0.575	0.073	0.000	-0.521	0.000	0.000	0.000	0.000	-0.026
Binghamton	0.034	0.182	-0.014	-0.148	0.169	0.000	-0.603	0.182	0.000	-0.313	0.000	0.000	0.000	0.000	-0.014
Buffalo	0.040	0.171	-0.027	-0.230	0.190	0.000	-0.655	0.171	0.000	-0.551	0.000	0.000	0.000	0.000	-0.027
Massena	0.034	0.112	-0.029	-0.298	0.131	0.000	-0.489	0.112	0.000	-0.607	0.000	0.000	0.000	0.000	-0.029
NYC	0.077	0.085	-0.023	-0.105	0.111	0.000	-0.579	0.085	0.000	-0.403	0.000	0.000	0.000	0.000	-0.023
Poughkeepsie	0.060	0.079	-0.025	-0.160	0.115	0.000	-0.577	0.079	0.000	-0.462	0.000	0.000	0.000	0.000	-0.025
Syracuse	0.045	0.095	-0.019	-0.157	0.119	0.000	-0.615	0.095	0.000	-0.382	0.000	0.000	0.000	0.000	-0.019

MULTI-FAMILY LOW-RISE

	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
City	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.020	0.128	-0.017	-0.140	0.150	0.000	-0.329	0.128	0.000	-0.363	0.000	0.000	-0.014	0.000	-0.017
Binghamton	0.003	0.137	-0.018	-0.178	0.151	0.000	-0.384	0.137	0.000	-0.407	0.000	0.000	-0.020	0.000	-0.018
Buffalo	0.014	0.142	-0.017	-0.143	0.157	0.000	-0.332	0.142	0.000	-0.359	0.000	0.000	-0.014	0.000	-0.017
Massena	0.015	0.158	-0.018	-0.161	0.181	0.000	-0.349	0.158	0.000	-0.377	0.000	0.000	-0.013	0.000	-0.018
NYC	0.055	0.136	-0.016	-0.064	0.163	0.000	-0.260	0.136	0.000	-0.320	0.000	0.000	-0.005	0.000	-0.016
Poughkeepsie	0.038	0.132	-0.017	-0.102	0.157	0.000	-0.295	0.132	0.000	-0.342	0.000	0.000	-0.010	0.000	-0.017
Syracuse	0.017	0.140	-0.018	-0.160	0.150	0.000	-0.361	0.140	0.000	-0.391	0.000	0.000	-0.013	0.000	-0.018

MULTI-FAMILY HIGH-RISE

	Fan coil with chiller and hot water boiler			Steam heat only		
City	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.080	0.113	-0.025	0.000	0.000	-0.028

City	Fan coil with chiller and hot water boiler			Steam heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Binghamton	0.068	0.073	-0.027	0.000	0.000	-0.030
Buffalo	0.072	0.113	-0.026	0.000	0.000	-0.029
Massena	0.073	0.094	-0.026	0.000	0.000	-0.029
NYC	0.101	0.194	-0.021	0.000	0.000	-0.024
Poughkeepsie	0.092	0.168	-0.023	0.000	0.000	-0.026
Syracuse	0.080	0.113	-0.024	0.000	0.000	-0.027

SMALL COMMERCIAL BUILDINGS

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Assembly (Asy)	Albany	0.100	0.200	-0.031	-0.388	0.200	0.000	-0.536	0.200	0.000	-0.644	0.000	0.000	0.000	0.000	-0.032
	Binghamton	0.090	0.200	-0.036	-0.444	0.200	0.000	-0.676	0.200	0.000	-0.778	0.000	0.000	0.000	0.000	-0.036
	Buffalo	0.100	0.200	-0.034	-0.405	0.200	0.000	-0.645	0.200	0.000	-0.757	0.000	0.000	0.000	0.000	-0.036
	Massena	0.090	0.200	-0.041	-0.491	0.200	0.000	-0.653	0.200	0.000	-0.764	0.000	0.000	0.000	0.000	-0.037
	NYC	0.160	0.200	-0.021	-0.052	0.200	0.000	-0.243	0.200	0.000	-0.400	0.000	0.000	0.000	0.000	-0.020
	Poughkeepsie	0.130	0.200	-0.026	-0.361	0.200	0.000	-0.578	0.200	0.000	-0.700	0.000	0.000	0.000	0.000	-0.034
	Syracuse	0.110	0.200	-0.029	-0.364	0.200	0.000	-0.481	0.200	0.000	-0.610	0.000	0.000	0.000	0.000	-0.029
Auto repair (AR)	Albany	0.044	0.200	-0.032	-0.377	0.200	0.000	-0.630	0.200	0.000	-0.699	0.000	0.000	0.000	0.000	-0.032
	Binghamton	0.038	0.200	-0.028	-0.345	0.200	0.000	-0.564	0.200	0.000	-0.614	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.043	0.200	-0.033	-0.316	0.200	0.000	-0.661	0.200	0.000	-0.724	0.000	0.000	0.000	0.000	-0.033
	Massena	0.039	0.200	-0.033	-0.443	0.200	0.000	-0.653	0.200	0.000	-0.715	0.000	0.000	0.000	0.000	-0.033
	NYC	0.076	0.200	-0.041	-0.308	0.200	0.000	-0.795	0.200	0.000	-0.891	0.000	0.000	0.000	0.000	-0.042
	Poughkeepsie	0.057	0.200	-0.037	-0.408	0.200	0.000	-0.726	0.200	0.000	-0.811	0.000	0.000	0.000	0.000	-0.037
	Syracuse	0.046	0.200	-0.036	-0.394	0.200	0.000	-0.727	0.200	0.000	-0.809	0.000	0.000	0.000	0.000	-0.037
Big Box (BB)	Albany	0.120	0.200	-0.023	-0.166	0.200	0.000	-0.330	0.200	0.000	-0.458	0.000	0.000	0.000	0.000	-0.023
	Binghamton	0.110	0.200	-0.023	-0.172	0.200	0.000	-0.330	0.200	0.000	-0.462	0.000	0.000	0.000	0.000	-0.023
	Buffalo	0.110	0.200	-0.023	-0.163	0.200	0.000	-0.299	0.200	0.000	-0.424	0.000	0.000	0.000	0.000	-0.022
	Massena	0.100	0.200	-0.027	-0.298	0.200	0.000	-0.463	0.200	0.000	-0.572	0.000	0.000	0.000	0.000	-0.028
	NYC	0.170	0.200	-0.013	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.145	0.200	-0.018	-0.085	0.200	0.000	-0.200	0.200	0.000	-0.350	0.000	0.000	0.000	0.000	-0.019
	Syracuse	0.120	0.200	-0.022	-0.144	0.200	0.000	-0.301	0.200	0.000	-0.425	0.000	0.000	0.000	0.000	-0.021
Elementary School	Albany	0.060	0.200	-0.039	-0.399	0.200	0.000	-0.809	0.200	0.000	-0.916	0.000	0.000	0.000	0.000	-0.040
	Binghamton	0.040	0.200	-0.041	-0.406	0.200	0.000	-0.818	0.200	0.000	-0.950	0.000	0.000	0.000	0.000	-0.042

		AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
Building	**City**	**HVACc**	**HVACd**	**HVACg**	**HVACc**	**HVACd**	**HVACg**	**HVACc**	**HVACd**	**HVACg**	**HVACc**	**HVACd**	**HVACg**	**HVACc**	**HVACd**	**HVACg**
(Elem)	Buffalo	0.040	0.200	-0.041	-0.382	0.200	0.000	-0.773	0.200	0.000	-0.908	0.000	0.000	0.000	0.000	-0.040
	Massena	0.040	0.200	-0.044	-0.509	0.200	0.000	-0.850	0.200	0.000	-0.963	0.000	0.000	0.000	0.000	-0.042
	NYC	0.110	0.200	-0.029	-0.150	0.200	0.000	-0.481	0.200	0.000	-0.646	0.000	0.000	0.000	0.000	-0.029
	Poughkeepsie	0.085	0.200	-0.034	-0.327	0.200	0.000	-0.743	0.200	0.000	-0.907	0.000	0.000	0.000	0.000	-0.040
	Syracuse	0.060	0.200	-0.039	-0.385	0.200	0.000	-0.778	0.200	0.000	-0.902	0.000	0.000	0.000	0.000	-0.040
Fast Food (FF)	Albany	0.070	0.200	-0.037	-0.702	0.200	0.000	-0.702	0.200	0.000	-0.818	0.000	0.000	0.000	0.000	-0.039
	Binghamton	0.060	0.200	-0.035	-0.732	0.200	0.000	-0.732	0.200	0.000	-0.808	0.000	0.000	0.000	0.000	-0.038
	Buffalo	0.070	0.200	-0.036	-0.677	0.200	0.000	-0.677	0.200	0.000	-0.815	0.000	0.000	0.000	0.000	-0.038
	Massena	0.070	0.200	-0.036	-0.717	0.200	0.000	-0.717	0.200	0.000	-0.814	0.000	0.000	0.000	0.000	-0.039
	NYC	0.110	0.200	-0.028	-0.471	0.200	0.000	-0.471	0.200	0.000	-0.827	0.000	0.000	0.000	0.000	-0.040
	Poughkeepsie	0.090	0.200	-0.033	-0.660	0.200	0.000	-0.660	0.200	0.000	-0.816	0.000	0.000	0.000	0.000	-0.039
	Syracuse	0.070	0.200	-0.035	-0.682	0.200	0.000	-0.682	0.200	0.000	-0.817	0.000	0.000	0.000	0.000	-0.039
Full Service Restaurant (FS)	Albany	0.070	0.200	-0.039	-0.656	0.200	0.000	-0.656	0.200	0.000	-0.792	0.000	0.000	0.000	0.000	-0.037
	Binghamton	0.060	0.200	-0.038	-0.738	0.200	0.000	-0.738	0.200	0.000	-0.856	0.000	0.000	0.000	0.000	-0.041
	Buffalo	0.070	0.200	-0.037	-0.645	0.200	0.000	-0.645	0.200	0.000	-0.777	0.000	0.000	0.000	0.000	-0.037
	Massena	0.060	0.200	-0.038	-0.720	0.200	0.000	-0.720	0.200	0.000	-0.821	0.000	0.000	0.000	0.000	-0.039
	NYC	0.110	0.200	-0.030	-0.486	0.200	0.000	-0.486	0.200	0.000	-0.637	0.000	0.000	0.000	0.000	-0.032
	Poughkeepsie	0.090	0.200	-0.035	-0.573	0.200	0.000	-0.573	0.200	0.000	-0.756	0.000	0.000	0.000	0.000	-0.037
	Syracuse	0.080	0.200	-0.037	-0.631	0.200	0.000	-0.631	0.200	0.000	-0.762	0.000	0.000	0.000	0.000	-0.036
Grocery	Albany	0.120	0.200	-0.023	-0.166	0.200	0.000	-0.330	0.200	0.000	-0.458	0.000	0.000	0.000	0.000	-0.023
	Binghamton	0.110	0.200	-0.023	-0.172	0.200	0.000	-0.330	0.200	0.000	-0.462	0.000	0.000	0.000	0.000	-0.023
	Buffalo	0.110	0.200	-0.023	-0.163	0.200	0.000	-0.299	0.200	0.000	-0.424	0.000	0.000	0.000	0.000	-0.022
	Massena	0.100	0.200	-0.027	-0.298	0.200	0.000	-0.463	0.200	0.000	-0.572	0.000	0.000	0.000	0.000	-0.028
	NYC	0.170	0.200	-0.013	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.145	0.200	-0.018	-0.085	0.200	0.000	-0.200	0.200	0.000	-0.350	0.000	0.000	0.000	0.000	-0.019
	Syracuse	0.120	0.200	-0.022	-0.144	0.200	0.000	-0.301	0.200	0.000	-0.425	0.000	0.000	0.000	0.000	-0.021
Light Industrial (Ind)	Albany	0.070	0.200	-0.026	-0.213	0.200	0.000	-0.456	0.200	0.000	-0.539	0.000	0.000	0.000	0.000	-0.026
	Binghamton	0.060	0.200	-0.028	-0.277	0.200	0.000	-0.507	0.200	0.000	-0.582	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.060	0.200	-0.028	-0.236	0.200	0.000	-0.474	0.200	0.000	-0.550	0.000	0.000	0.000	0.000	-0.027
	Massena	0.060	0.200	-0.028	-0.286	0.200	0.000	-0.490	0.200	0.000	-0.568	0.000	0.000	0.000	0.000	-0.027
	NYC	0.100	0.200	-0.021	-0.083	0.200	0.000	-0.313	0.200	0.000	-0.415	0.000	0.000	0.000	0.000	-0.020
	Poughkeepsie	0.085	0.200	-0.024	-0.165	0.200	0.000	-0.399	0.200	0.000	-0.491	0.000	0.000	0.000	0.000	-0.024
	Syracuse	0.070	0.200	-0.026	-0.218	0.200	0.000	-0.459	0.200	0.000	-0.542	0.000	0.000	0.000	0.000	-0.026
Motel (Motel)	Albany	0.080	0.200	-0.027	-0.318	0.200	0.000	-0.485	0.200	0.000	-0.586	0.000	0.000	0.000	0.000	-0.028
	Binghamton	0.069	0.200	-0.028	-0.342	0.200	0.000	-0.519	0.200	0.000	-0.613	0.000	0.000	0.000	0.000	-0.029
	Buffalo	0.073	0.200	-0.028	-0.314	0.200	0.000	-0.495	0.200	0.000	-0.597	0.000	0.000	0.000	0.000	-0.028
	Massena	0.068	0.200	-0.030	-0.383	0.200	0.000	-0.537	0.200	0.000	-0.627	0.000	0.000	0.000	0.000	-0.029

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
	NYC	0.114	0.200	-0.023	-0.155	0.200	0.000	-0.340	0.200	0.000	-0.482	0.000	0.000	0.000	0.000	-0.023
	Poughkeepsie	0.097	0.200	-0.025	-0.271	0.200	0.000	-0.453	0.200	0.000	-0.577	0.000	0.000	0.000	0.000	-0.027
	Syracuse	0.081	0.200	-0.027	-0.313	0.200	0.000	-0.485	0.200	0.000	-0.591	0.000	0.000	0.000	0.000	-0.028
Religious (Rel)	Albany	0.078	0.200	-0.012	-0.119	0.200	0.000	-0.193	0.200	0.000	-0.274	0.000	0.000	0.000	0.000	-0.012
	Binghamton	0.071	0.200	-0.013	-0.122	0.200	0.000	-0.229	0.200	0.000	-0.309	0.000	0.000	0.000	0.000	-0.013
	Buffalo	0.075	0.200	-0.011	-0.117	0.200	0.000	-0.194	0.200	0.000	-0.272	0.000	0.000	0.000	0.000	-0.012
	Massena	0.069	0.200	-0.013	-0.151	0.200	0.000	-0.219	0.200	0.000	-0.289	0.000	0.000	0.000	0.000	-0.013
	NYC	0.092	0.200	-0.013	-0.060	0.200	0.000	-0.199	0.200	0.000	-0.291	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.089	0.200	-0.013	-0.078	0.200	0.000	-0.220	0.200	0.000	-0.310	0.000	0.000	0.000	0.000	-0.013
	Syracuse	0.081	0.200	-0.012	-0.118	0.200	0.000	-0.204	0.200	0.000	-0.285	0.000	0.000	0.000	0.000	-0.012
Small Office (SOfc)	Albany	0.100	0.200	-0.019	-0.112	0.200	0.000	-0.283	0.200	0.000	-0.376	0.000	0.000	0.000	0.000	-0.019
	Binghamton	0.090	0.200	-0.021	-0.145	0.200	0.000	-0.321	0.200	0.000	-0.413	0.000	0.000	0.000	0.000	-0.021
	Buffalo	0.090	0.200	-0.020	-0.129	0.200	0.000	-0.307	0.200	0.000	-0.405	0.000	0.000	0.000	0.000	-0.020
	Massena	0.090	0.200	-0.021	-0.177	0.200	0.000	-0.333	0.200	0.000	-0.426	0.000	0.000	0.000	0.000	-0.021
	NYC	0.120	0.200	-0.015	-0.003	0.200	0.000	-0.157	0.200	0.000	-0.239	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.110	0.200	-0.017	-0.061	0.200	0.000	-0.219	0.200	0.000	-0.335	0.000	0.000	0.000	0.000	-0.017
	Syracuse	0.100	0.200	-0.020	-0.119	0.200	0.000	-0.286	0.200	0.000	-0.383	0.000	0.000	0.000	0.000	-0.019
Small Retail (SRet)	Albany	0.100	0.200	-0.027	-0.191	0.200	0.000	-0.428	0.200	0.000	-0.555	0.000	0.000	0.000	0.000	-0.027
	Binghamton	0.090	0.200	-0.029	-0.190	0.200	0.000	-0.448	0.200	0.000	-0.568	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.090	0.200	-0.028	-0.205	0.200	0.000	-0.447	0.200	0.000	-0.555	0.000	0.000	0.000	0.000	-0.027
	Massena	0.080	0.200	-0.031	-0.264	0.200	0.000	-0.535	0.200	0.000	-0.632	0.000	0.000	0.000	0.000	-0.031
	NYC	0.130	0.200	-0.022	-0.044	0.200	0.000	-0.258	0.200	0.000	-0.375	0.000	0.000	0.000	0.000	-0.019
	Poughkeepsie	0.115	0.200	-0.025	-0.137	0.200	0.000	-0.350	0.200	0.000	-0.481	0.000	0.000	0.000	0.000	-0.024
	Syracuse	0.090	0.200	-0.028	-0.180	0.200	0.000	-0.451	0.200	0.000	-0.563	0.000	0.000	0.000	0.000	-0.028
Warehouse (WH)	Albany	0.063	0.200	-0.016	-0.170	0.200	0.000	-0.311	0.200	0.000	-0.373	0.000	0.000	0.000	0.000	-0.016
	Binghamton	0.054	0.200	-0.017	-0.187	0.200	0.000	-0.341	0.200	0.000	-0.397	0.000	0.000	0.000	0.000	-0.017
	Buffalo	0.054	0.200	-0.016	-0.178	0.200	0.000	-0.325	0.200	0.000	-0.380	0.000	0.000	0.000	0.000	-0.016
	Massena	0.055	0.200	-0.014	-0.156	0.200	0.000	-0.280	0.200	0.000	-0.335	0.000	0.000	0.000	0.000	-0.014
	NYC	0.078	0.200	-0.015	-0.109	0.200	0.000	-0.273	0.200	0.000	-0.352	0.000	0.000	0.000	0.000	-0.015
	Poughkeepsie	0.073	0.200	-0.017	-0.127	0.200	0.000	-0.312	0.200	0.000	-0.388	0.000	0.000	0.000	0.000	-0.017
	Syracuse	0.066	0.200	-0.017	-0.205	0.200	0.000	-0.334	0.200	0.000	-0.401	0.000	0.000	0.000	0.000	-0.017
Other	Albany	0.080	0.200	-0.027	-0.318	0.200	0.000	-0.485	0.200	0.000	-0.586	0.000	0.000	0.000	0.000	-0.028
	Binghamton	0.069	0.200	-0.028	-0.342	0.200	0.000	-0.519	0.200	0.000	-0.613	0.000	0.000	0.000	0.000	-0.029
	Buffalo	0.073	0.200	-0.028	-0.314	0.200	0.000	-0.495	0.200	0.000	-0.597	0.000	0.000	0.000	0.000	-0.028
	Massena	0.068	0.200	-0.030	-0.383	0.200	0.000	-0.537	0.200	0.000	-0.627	0.000	0.000	0.000	0.000	-0.029
	NYC	0.114	0.200	-0.023	-0.155	0.200	0.000	-0.340	0.200	0.000	-0.482	0.000	0.000	0.000	0.000	-0.023
	Poughkeepsie	0.097	0.200	-0.025	-0.271	0.200	0.000	-0.453	0.200	0.000	-0.577	0.000	0.000	0.000	0.000	-0.027

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
	Syracuse	0.081	0.200	-0.027	-0.313	0.200	0.000	-0.485	0.200	0.000	-0.591	0.000	0.000	0.000	0.000	-0.028

LARGE COMMERCIAL BUILDINGS

Building	City	CV Noecon			CV Econ			VAV Econ		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Community College (CC)	Albany	0.045	0.200	-0.014	0.016	0.200	-0.015	0.080	0.200	-0.007
	Binghamton	0.042	0.200	-0.009	0.014	0.200	-0.010	0.064	0.200	-0.005
	Buffalo	0.042	0.200	-0.011	0.014	0.200	-0.012	0.065	0.200	-0.005
	Massena	0.040	0.200	-0.015	0.013	0.200	-0.015	0.043	0.200	-0.008
	NYC	0.044	0.200	-0.025	0.019	0.200	-0.024	0.124	0.200	-0.003
	Poughkeepsie	0.040	0.200	-0.022	0.014	0.200	-0.021	0.083	0.200	-0.009
	Syracuse	0.045	0.200	-0.017	0.016	0.200	-0.017	0.087	0.200	-0.005
High School (HS)	Albany	0.033	0.200	-0.027	0.014	0.200	-0.027	0.037	0.200	-0.021
	Binghamton	0.028	0.200	-0.028	0.009	0.200	-0.028	0.030	0.200	-0.022
	Buffalo	0.031	0.200	-0.027	0.010	0.200	-0.027	0.035	0.200	-0.021
	Massena	0.030	0.200	-0.028	0.012	0.200	-0.027	0.026	0.200	-0.023
	NYC	0.042	0.200	-0.026	0.022	0.200	-0.025	0.049	0.200	-0.020
	Poughkeepsie	0.037	0.200	-0.028	0.016	0.200	-0.027	0.034	0.200	-0.023
	Syracuse	0.033	0.200	-0.028	0.015	0.200	-0.027	0.037	0.200	-0.022
Hospital (Hosp)	Albany	0.029	0.200	-0.021	0.014	0.200	-0.021	0.045	0.200	-0.016
	Binghamton	0.027	0.200	-0.021	0.011	0.200	-0.021	0.039	0.200	-0.015
	Buffalo	0.027	0.200	-0.021	0.012	0.200	-0.021	0.044	0.200	-0.015
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015
Hotel (Hotel)	Albany	0.029	0.200	-0.021	0.014	0.200	-0.021	0.045	0.200	-0.016
	Binghamton	0.027	0.200	-0.021	0.011	0.200	-0.021	0.039	0.200	-0.015
	Buffalo	0.027	0.200	-0.021	0.012	0.200	-0.021	0.044	0.200	-0.015
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015
Large Office (LOfc)	Albany	0.029	0.200	-0.021	0.014	0.200	-0.021	0.045	0.200	-0.016
	Binghamton	0.027	0.200	-0.021	0.011	0.200	-0.021	0.039	0.200	-0.015
	Buffalo	0.027	0.200	-0.021	0.012	0.200	-0.021	0.044	0.200	-0.015

Building	City	CV Noecon			CV Econ			VAV Econ		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015
Large Retail (LRet)	Albany	0.031	0.200	-0.027	0.018	0.200	-0.027	0.043	0.200	-0.024
	Binghamton	0.032	0.200	-0.027	0.015	0.200	-0.028	0.044	0.200	-0.023
	Buffalo	0.030	0.200	-0.026	0.017	0.200	-0.028	0.045	0.200	-0.022
	Massena	0.029	0.200	-0.028	0.016	0.200	-0.029	0.036	0.200	-0.026
	NYC	0.037	0.200	-0.023	0.023	0.200	-0.024	0.057	0.200	-0.017
	Poughkeepsie	0.033	0.200	-0.025	0.018	0.200	-0.025	0.056	0.200	-0.019
	Syracuse	0.032	0.200	-0.027	0.017	0.200	-0.029	0.044	0.200	-0.024
University (Univ)	Albany	0.051	0.200	-0.023	0.018	0.200	-0.025	0.111	0.200	-0.012
	Binghamton	0.049	0.200	-0.019	0.014	0.200	-0.020	0.098	0.200	-0.012
	Buffalo	0.052	0.200	-0.020	0.018	0.200	-0.022	0.104	0.200	-0.012
	Massena	0.042	0.200	-0.025	0.012	0.200	-0.027	0.086	0.200	-0.014
	NYC	0.048	0.200	-0.027	0.020	0.200	-0.028	0.142	0.200	-0.010
	Poughkeepsie	0.044	0.200	-0.027	0.014	0.200	-0.028	0.120	0.200	-0.009
	Syracuse	0.047	0.200	-0.024	0.016	0.200	-0.026	0.110	0.200	-0.012

COLLEGE DORMITORY

City	Fan coil with chiller and hot water boiler			Steam heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.029	.200	-0.014	0.000	0.000	-0.015
Binghamton	0.029	.200	-0.014	0.000	0.000	-0.016
Buffalo	0.027	.200	-0.014	0.000	0.000	-0.016
Massena	0.025	.200	-0.015	0.000	0.000	-0.016
NYC	0.025	.200	-0.012	0.000	0.000	-0.013
Poughkeepsie	0.035	.200	-0.014	0.000	0.000	-0.015
Syracuse	0.028	.200	-0.014	0.000	0.000	-0.016

REFRIGERATED WAREHOUSE

City	Water Cooled Ammonia Screw Compressors	
	HVACc	HVACd
Albany	0.370	.200
Binghamton	0.400	.200

Buffalo	0.400	.200
Massena	0.390	.200
NYC	0.390	.200
Poughkeepsie	0.410	.200
Syracuse	0.390	.200

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010

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APPENDIX E

OPAQUE SHELL MEASURE SAVINGS

SINGLE-FAMILY RESIDENTIAL INSULATION UPGRADES

Building: Single-Family Low-rise City: Albany HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	51.2	0.065	51.9												
13	58.7	0.076	60.3	7.6	0.011	8.3									
17	70.2	0.098	72.1	19.1	0.033	20.2	11.5	0.022	11.8						
19	74.1	0.098	76.4	23.0	0.033	24.5	15.4	0.022	16.2	3.9	0.000	4.3			
21	77.9	0.108	80.0	26.8	0.043	28.1	19.2	0.033	19.7	7.7	0.011	7.9	3.8	0.011	3.6
25	83.0	0.108	85.6	31.9	0.043	33.7	24.3	0.033	25.4	12.8	0.011	13.5	8.9	0.011	9.2
27	85.3	0.119	87.9	34.1	0.054	36.0	26.6	0.043	15.8	15.1	0.022	15.8	11.2	0.022	11.5

Building: Single-Family City: Albany HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	772.8	0.043								
13	896.3	0.054	123.5	0.011						
17	1065.6	0.065	292.8	0.022	169.3	0.011				
19	1126.6	0.076	353.8	0.033	230.3	0.022	61.0	0.011		
21	1178.0	0.076	405.2	0.033	281.7	0.022	112.4	0.011	51.4	0.000
25	1257.9	0.076	485.0	0.033	361.6	0.022	192.3	0.011	131.3	0.000
27	1290.5	0.087	517.7	0.043	224.9	0.033	224.9	0.022	163.9	0.011

Building: Single-Family City: Albany HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1192.1	0.065								
13	1382.2	0.076	190.1	0.011						
17	1650.6	0.098	458.5	0.033	268.4	0.022				
19	1748.1	0.098	556.0	0.033	365.9	0.022	97.6	0.000		
21	1830.2	0.108	638.1	0.043	448.0	0.033	179.6	0.011	82.1	0.011
25	1958.5	0.108	766.4	0.043	576.3	0.033	307.9	0.011	210.4	0.011
27	2010.2	0.119	818.1	0.054	628.0	0.043	359.6	0.022	262.1	0.022

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

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1166.2	0.000								
13	1352.7	0.000	186.5	0.000						
17	1615.2	0.000	449.1	0.000	262.5	0.000				
19	1710.9	0.000	544.8	0.000	358.2	0.000	95.7	0.000		
21	1790.9	0.000	624.8	0.000	438.2	0.000	175.7	0.000	80.0	0.000
25	1916.9	0.000	750.7	0.000	564.2	0.000	301.6	0.000	205.9	0.000
27	1967.4	0.000	801.2	0.000	614.7	0.000	352.2	0.000	256.4	0.000

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

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	25.1	0.000	51.9												
13	29.2	0.000	60.3	4.0	0.000	8.3									
17	34.9	0.000	72.1	9.8	0.000	20.2	5.7	0.000	11.8						
19	37.0	0.000	76.4	11.8	0.000	24.5	7.8	0.000	16.2	2.1	0.000	4.3			
21	38.7	0.000	80.0	13.5	0.000	28.1	9.5	0.000	19.7	3.8	0.000	7.9	1.7	0.000	3.6
25	41.4	0.000	85.6	16.3	0.000	33.7	12.2	0.000	25.4	6.5	0.000	13.5	4.4	0.000	9.2
27	42.5	0.000	87.9	17.3	0.000	36.0	13.3	0.000	27.6	7.6	0.000	15.8	5.5	0.000	11.5

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

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	336.9	0.119	322.4												
19	380.5	0.188	362.3	43.7	0.068	39.9									
30	403.4	0.222	385.8	66.6	0.102	63.5	22.9	0.034	23.5						
38	414.8	0.239	395.1	78.0	0.119	72.7	34.3	0.051	32.8	11.4	0.017	9.2			
49	421.2	0.239	403.1	84.3	0.119	80.7	40.6	0.051	40.8	17.7	0.017	17.2	6.3	0.000	8.0
60	425.4	0.256	408.4	88.6	0.137	86.0	44.9	0.068	46.1	22.0	0.034	22.5	10.6	0.017	13.3

Building: Single-Family City: Albany HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5582.8	0.188								
19	6213.0	0.239	630.2	0.051						
30	6570.8	0.273	988.1	0.085	357.8	0.034				
38	6710.4	0.273	1127.6	0.085	497.4	0.034	139.6	0.000		
49	6828.0	0.290	1245.2	0.102	615.0	0.051	257.2	0.017	117.6	0.017
60	6904.8	0.290	1322.0	0.102	691.8	0.051	334.0	0.017	194.4	0.017

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

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7631.9	0.119								
19	8563.5	0.188	931.6	0.068						
30	9106.8	0.222	1474.9	0.102	543.3	0.034				
38	9320.3	0.239	1688.4	0.119	756.8	0.051	213.5	0.017		
49	9502.6	0.239	1870.6	0.119	939.1	0.051	395.7	0.017	182.3	0.000
60	9621.8	0.256	1989.9	0.137	1058.4	0.068	515.0	0.034	301.5	0.017

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

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7449.5	0.000								
19	8356.1	0.000	906.7	0.000						
30	8887.5	0.000	1438.1	0.000	531.4	0.000				
38	9093.9	0.000	1644.4	0.000	737.7	0.000	206.3	0.000		
49	9273.5	0.000	1824.1	0.000	917.4	0.000	386.0	0.000	179.7	0.000
60	9391.0	0.000	1941.5	0.000	1034.8	0.000	503.4	0.000	297.1	0.000

Building: Single-Family City: Albany HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	154.6	0.000	322.5												
19	173.4	0.000	362.5	18.8	0.000	39.9									
30	184.3	0.000	386.0	29.7	0.000	63.5	10.9	0.000	23.5						
38	188.6	0.000	395.2	34.0	0.000	72.7	15.2	0.000	32.8	4.3	0.000	9.2			
49	192.3	0.000	403.2	37.7	0.000	80.7	18.9	0.000	40.8	8.0	0.000	17.2	3.8	0.000	8.0
60	194.7	0.000	408.5	40.1	0.000	86.0	21.3	0.000	46.1	10.4	0.000	22.5	6.1	0.000	13.3

Building: Single-Family City: Buffalo HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	46.4	0.043	54.2												
13	53.7	0.043	62.8	7.3	0.000	8.6									
17	64.9	0.054	74.9	18.5	0.011	20.7	11.3	0.011	12.1						
19	68.6	0.054	79.3	22.2	0.011	25.1	15.0	0.011	16.6	3.7	0.000	4.4			
21	71.3	0.054	83.0	24.9	0.011	28.8	17.7	0.011	20.3	6.4	0.000	8.1	2.7	0.000	3.7
25	76.0	0.054	88.9	29.6	0.011	34.7	22.3	0.011	26.1	11.1	0.000	14.0	7.4	0.000	9.5
27	77.0	0.065	91.2	30.6	0.022	37.0	23.3	0.022	16.3	12.0	0.011	16.3	8.3	0.011	11.8

Building: Single-Family City: Buffalo HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	841.3	0.043								
13	972.3	0.043	130.9	0.000						
17	1154.8	0.054	313.5	0.011	182.5	0.011				
19	1221.2	0.054	379.9	0.011	249.0	0.011	66.4	0.000		
21	1275.0	0.054	433.7	0.011	302.7	0.011	120.2	0.000	53.8	0.000
25	1360.1	0.065	518.8	0.022	387.8	0.022	205.3	0.011	138.8	0.011
27	1394.0	0.065	552.7	0.022	239.2	0.022	239.2	0.011	172.8	0.011

Building: Single-Family City: Buffalo HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1246.8	0.043								
13	1444.4	0.043	197.6	0.000						
17	1722.6	0.054	475.8	0.011	278.2	0.011				
19	1823.7	0.054	576.8	0.011	379.3	0.011	101.0	0.000		
21	1907.4	0.054	660.6	0.011	463.0	0.011	184.8	0.000	83.8	0.000
25	2039.8	0.054	793.0	0.011	595.4	0.011	317.1	0.000	216.1	0.000
27	2091.9	0.065	845.1	0.022	647.5	0.022	369.3	0.011	268.3	0.011

Building: Single-Family City: Buffalo HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1227.4	0.000								
13	1422.0	0.000	194.6	0.000						
17	1694.9	0.000	467.5	0.000	272.9	0.000				
19	1794.4	0.000	567.0	0.000	372.4	0.000	99.5	0.000		
21	1877.4	0.000	650.0	0.000	455.5	0.000	182.5	0.000	83.0	0.000
25	2007.9	0.000	780.5	0.000	586.0	0.000	313.0	0.000	213.5	0.000
27	2060.2	0.000	832.8	0.000	638.2	0.000	365.3	0.000	265.8	0.000

Building: Single-Family City: Buffalo HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	26.9	0.000	54.2												
13	31.2	0.000	62.8	4.3	0.000	8.6									
17	37.2	0.000	74.9	10.3	0.000	20.7	6.0	0.000	12.1						
19	39.3	0.000	79.3	12.5	0.000	25.1	8.1	0.000	16.6	2.2	0.000	4.4			
21	41.2	0.000	83.0	14.3	0.000	28.8	10.0	0.000	20.3	4.0	0.000	8.1	1.8	0.000	3.7
25	44.0	0.000	88.9	17.1	0.000	34.7	12.8	0.000	26.1	6.8	0.000	14.0	4.7	0.000	9.5
27	45.2	0.000	91.3	18.3	0.000	37.1	14.0	0.000	28.5	8.0	0.000	16.4	5.9	0.000	11.9

Building: Single-Family City: Buffalo HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	292.5	0.256	320.6												
19	327.0	0.290	360.6	34.5	0.034	39.9									
30	350.3	0.307	384.0	57.8	0.051	63.3	23.4	0.017	23.4						
38	357.0	0.324	393.2	64.5	0.068	72.5	30.0	0.034	32.6	6.7	0.017	9.2			
49	366.7	0.324	401.2	74.2	0.068	80.5	39.8	0.034	40.6	16.4	0.017	17.2	9.7	0.000	8.0
60	370.5	0.324	406.5	78.0	0.068	85.8	43.5	0.034	45.9	20.1	0.017	22.5	13.5	0.000	13.3

Building: Single-Family City: Buffalo HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5565.7	0.239								
19	6216.2	0.273	650.5	0.034						
30	6586.5	0.307	1020.8	0.068	370.3	0.034				
38	6729.7	0.307	1164.0	0.068	513.5	0.034	143.2	0.000		
49	6857.7	0.307	1292.0	0.068	641.5	0.034	271.2	0.000	128.0	0.000
60	6938.4	0.307	1372.7	0.068	722.2	0.034	351.9	0.000	208.7	0.000

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

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7602.2	0.256								
19	8528.5	0.290	926.3	0.034						
30	9073.4	0.307	1471.2	0.051	544.9	0.017				
38	9284.0	0.324	1681.7	0.068	755.5	0.034	210.6	0.017		
49	9472.2	0.324	1870.0	0.068	943.7	0.034	398.8	0.017	188.2	0.000
60	9592.3	0.324	1990.1	0.068	1063.8	0.034	518.9	0.017	308.4	0.000

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

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7464.7	0.000								
19	8375.4	0.000	910.8	0.000						
30	8907.8	0.000	1443.2	0.000	532.4	0.000				
38	9116.2	0.000	1651.5	0.000	740.8	0.000	208.4	0.000		
49	9298.5	0.000	1833.8	0.000	923.0	0.000	390.6	0.000	182.3	0.000
60	9417.2	0.000	1952.6	0.000	1041.8	0.000	509.4	0.000	301.0	0.000

Building: Single-Family City: Buffalo HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	154.9	0.000	320.6												
19	173.9	0.000	360.6	18.9	0.000	39.9									
30	184.8	0.000	384.0	29.9	0.000	63.3	10.9	0.000	23.4						
38	189.2	0.000	393.2	34.3	0.000	72.5	15.4	0.000	32.6	4.4	0.000	9.2			
49	193.0	0.000	401.2	38.1	0.000	80.5	19.1	0.000	40.6	8.2	0.000	17.2	3.8	0.000	8.0
60	195.4	0.000	406.5	40.4	0.000	85.8	21.5	0.000	45.9	10.6	0.000	22.5	6.1	0.000	13.3

Building: Single-family City: Massena HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	53.2	0.065	61.7												
13	61.1	0.076	71.5	7.9	0.011	9.9									
17	72.9	0.087	85.5	19.7	0.022	23.8	11.8	0.011	14.0						
19	77.5	0.098	90.7	24.3	0.033	29.0	16.4	0.022	19.2	4.6	0.011	5.2			
21	80.2	0.098	94.9	27.0	0.033	33.3	19.1	0.022	23.4	7.3	0.011	9.4	2.7	0.000	4.2
25	87.4	0.108	101.7	34.1	0.043	40.0	26.2	0.033	30.1	14.4	0.022	16.2	9.9	0.011	10.9
27	89.4	0.108	104.4	36.2	0.043	42.7	28.3	0.033	18.9	16.5	0.022	18.9	11.9	0.011	13.7

Building: Single-family City: Massena HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1039.7	0.043								
13	1201.9	0.054	162.3	0.011						
17	1430.7	0.076	391.1	0.033	228.8	0.022				
19	1514.0	0.076	474.3	0.033	312.1	0.022	83.2	0.000		
21	1582.1	0.087	542.4	0.043	380.1	0.033	151.3	0.011	68.1	0.011
25	1688.9	0.098	649.3	0.054	487.0	0.043	258.2	0.022	174.9	0.022
27	1734.9	0.098	695.2	0.054	304.1	0.043	304.1	0.022	220.9	0.022

Building: Single-family City: Massena HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1423.9	0.065								
13	1651.2	0.076	227.3	0.011						
17	1971.8	0.087	547.9	0.022	320.6	0.011				
19	2089.2	0.098	665.3	0.033	438.0	0.022	117.4	0.011		
21	2186.2	0.098	762.3	0.033	535.0	0.022	214.4	0.011	97.0	0.000
25	2341.6	0.108	917.7	0.043	690.4	0.033	369.8	0.022	252.4	0.011
27	2403.2	0.108	979.3	0.043	752.0	0.033	431.4	0.022	314.0	0.011

Building: Single-family City: Massena HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1400.7	0.000								
13	1624.9	0.000	224.1	0.000						
17	1940.3	0.000	539.6	0.000	315.4	0.000				
19	2055.9	0.000	655.2	0.000	431.1	0.000	115.7	0.000		
21	2152.1	0.000	751.4	0.000	527.2	0.000	211.8	0.000	96.1	0.000
25	2303.6	0.000	902.9	0.000	678.7	0.000	363.3	0.000	247.7	0.000
27	2364.8	0.000	964.1	0.000	740.0	0.000	424.6	0.000	308.9	0.000

Building: Single-family City: Massena HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	30.0	0.000	61.7												
13	34.9	0.000	71.5	4.9	0.000	9.9									
17	41.6	0.000	85.5	11.6	0.000	23.8	6.7	0.000	14.0						
19	44.1	0.000	90.7	14.1	0.000	29.0	9.2	0.000	19.2	2.5	0.000	5.2			
21	46.2	0.000	94.9	16.2	0.000	33.3	11.3	0.000	23.4	4.6	0.000	9.4	2.1	0.000	4.2
25	49.4	0.000	101.8	19.4	0.000	40.1	14.5	0.000	30.2	7.8	0.000	16.3	5.3	0.000	11.1
27	50.7	0.000	104.5	20.7	0.000	42.8	15.8	0.000	33.0	9.1	0.000	19.0	6.6	0.000	13.8

Building: Single-family City: Massena HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	338.4	0.290	381.2												
19	377.0	0.341	429.0	38.6	0.051	47.8									
30	400.2	0.375	457.2	61.8	0.085	75.9	23.2	0.034	28.2						
38	412.5	0.392	468.3	74.1	0.102	87.0	35.5	0.051	39.2	12.3	0.017	11.1			
49	420.6	0.392	477.8	82.3	0.102	96.6	43.7	0.051	48.8	20.5	0.017	20.6	8.2	0.000	9.6
60	426.3	0.410	484.1	87.9	0.119	102.9	49.3	0.068	55.1	26.1	0.034	27.0	13.8	0.017	15.9

Building: Single-family City: Massena HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7099.8	0.222								
19	7936.3	0.273	836.5	0.051						
30	8425.4	0.290	1325.6	0.068	489.1	0.017				
38	8614.0	0.307	1514.2	0.085	677.6	0.034	188.6	0.017		
49	8776.5	0.307	1676.6	0.085	840.1	0.034	351.0	0.017	162.5	0.000
60	8883.6	0.324	1783.8	0.102	947.3	0.051	458.2	0.034	269.6	0.017

Building: Single-family City: Massena HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	9089.2	0.290								
19	10202.2	0.341	1113.0	0.051						
30	10854.3	0.375	1765.0	0.085	652.0	0.034				
38	11112.8	0.392	2023.5	0.102	910.6	0.051	258.5	0.017		
49	11336.0	0.392	2246.8	0.102	1133.8	0.051	481.7	0.017	223.2	0.000
60	11481.7	0.410	2392.5	0.119	1279.5	0.068	627.5	0.034	368.9	0.017

Building: Single-family City: Massena HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	8931.1	0.000								
19	10027.6	0.000	1096.6	0.000						
30	10670.0	0.000	1738.9	0.000	642.3	0.000				
38	10921.5	0.000	1990.4	0.000	893.9	0.000	251.5	0.000		
49	11140.6	0.000	2209.6	0.000	1113.0	0.000	470.6	0.000	219.1	0.000
60	11284.0	0.000	2352.9	0.000	1256.3	0.000	614.0	0.000	362.5	0.000

Building: Single-family City: Massena HVAC: Gas Heat, no AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	180.4	0.000	381.4												
19	202.9	0.000	429.2	22.5	0.000	47.8									
30	216.0	0.000	457.3	35.7	0.000	75.9	13.1	0.000	28.2						
38	221.3	0.000	468.4	41.0	0.000	87.0	18.4	0.000	39.2	5.3	0.000	11.1			
49	225.8	0.000	478.0	45.4	0.000	96.6	22.9	0.000	48.8	9.7	0.000	20.6	4.4	0.000	9.6
60	228.7	0.000	484.3	48.3	0.000	102.9	25.8	0.000	55.1	12.6	0.000	27.0	7.3	0.000	15.9

Building: Single-family **City: NYC** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	60.0	0.054	36.6												
13	66.7	0.065	42.3	6.6	0.011	5.6									
17	80.6	0.076	50.6	20.6	0.022	14.0	14.0	0.011	8.3						
19	85.8	0.076	53.7	25.8	0.022	17.0	19.2	0.011	11.4	5.2	0.000	3.0			
21	90.1	0.076	56.1	30.0	0.022	19.5	23.4	0.011	13.9	9.4	0.000	5.5	4.2	0.000	2.5
25	95.5	0.087	60.2	35.4	0.033	23.5	28.8	0.022	17.9	14.8	0.011	9.5	9.6	0.011	6.5
27	97.8	0.087	61.7	37.7	0.033	25.0	31.1	0.022	11.1	17.1	0.011	11.1	11.9	0.011	8.0

Building: **Single-family** **City: NYC** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	430.4	0.076								
13	493.8	0.087	63.4	0.011						
17	590.6	0.098	160.2	0.022	96.8	0.011				
19	626.1	0.108	195.6	0.033	132.2	0.022	35.4	0.011		
21	654.8	0.108	224.4	0.033	161.0	0.022	64.2	0.011	28.7	0.000
25	698.8	0.108	268.4	0.033	205.0	0.022	108.2	0.011	72.7	0.000
27	717.2	0.119	286.8	0.043	126.6	0.033	126.6	0.022	91.2	0.011

Building: **Single-family** **City: NYC** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	840.8	0.054								
13	968.0	0.065	127.2	0.011						
17	1158.0	0.076	317.3	0.022	190.0	0.011				
19	1227.4	0.076	386.6	0.022	259.4	0.011	69.4	0.000		
21	1284.8	0.076	444.1	0.022	316.8	0.011	126.8	0.000	57.4	0.000
25	1374.3	0.087	533.5	0.033	406.2	0.022	216.2	0.011	146.9	0.011
27	1410.1	0.087	569.4	0.033	442.1	0.022	252.1	0.011	182.7	0.011

Building: Single-family City: NYC HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	798.1	0.000								
13	921.6	0.000	123.6	0.000						
17	1101.2	0.000	303.2	0.000	179.6	0.000				
19	1166.7	0.000	368.6	0.000	245.1	0.000	65.5	0.000		
21	1221.5	0.000	423.5	0.000	299.9	0.000	120.3	0.000	54.8	0.000
25	1307.6	0.000	509.5	0.000	386.0	0.000	206.4	0.000	140.9	0.000
27	1341.6	0.000	543.6	0.000	420.0	0.000	240.4	0.000	174.9	0.000

Building: Single-family City: NYC HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	17.2	0.000	36.7												
13	19.8	0.000	42.4	2.6	0.000	5.6									
17	23.7	0.000	50.6	6.5	0.000	13.9	3.9	0.000	8.2						
19	25.1	0.000	53.8	7.9	0.000	17.0	5.3	0.000	11.4	1.4	0.000	3.1			
21	26.3	0.000	56.3	9.1	0.000	19.5	6.5	0.000	13.9	2.6	0.000	5.6	1.2	0.000	2.5
25	28.3	0.000	60.3	11.1	0.000	23.5	8.5	0.000	17.9	4.6	0.000	9.6	3.1	0.000	6.5
27	29.0	0.000	61.8	11.8	0.000	25.0	9.2	0.000	19.4	5.3	0.000	11.2	3.9	0.000	8.0

Building: Single-family City: NYC HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	415.2	0.307	224.4												
19	468.9	0.375	252.4	53.8	0.068	28.0									
30	497.8	0.392	268.6	82.6	0.085	44.2	28.8	0.017	16.2						
38	508.4	0.410	275.1	93.2	0.102	50.7	39.4	0.034	22.7	10.6	0.017	6.5			
49	515.2	0.410	280.5	100.0	0.102	56.1	46.2	0.034	28.2	17.4	0.017	11.9	6.8	0.000	5.5
60	521.8	0.427	284.1	106.7	0.119	59.7	52.9	0.051	31.7	24.1	0.034	15.5	13.5	0.017	9.0

Building: Single-family City: NYC HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	2988.4	0.341								
19	3333.1	0.410	344.7	0.068						
30	3528.3	0.461	539.9	0.119	195.2	0.051				
38	3604.4	0.478	616.0	0.137	271.3	0.068	76.1	0.017		
49	3665.9	0.478	677.5	0.137	332.8	0.068	137.5	0.017	61.4	0.000
60	3708.9	0.495	720.5	0.154	375.8	0.085	180.5	0.034	104.4	0.017

Building: Single-family City: NYC HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5338.7	0.307								
19	5996.6	0.375	657.8	0.068						
30	6373.9	0.392	1035.2	0.085	377.3	0.017				
38	6520.6	0.410	1181.9	0.102	524.1	0.034	146.8	0.017		
49	6646.8	0.410	1308.0	0.102	650.2	0.034	272.9	0.017	126.1	0.000
60	6731.1	0.427	1392.3	0.119	734.5	0.051	357.2	0.034	210.4	0.017

Building: Single-family City: NYC HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5028.7	0.000								
19	5645.6	0.000	616.9	0.000						
30	6001.4	0.000	972.7	0.000	355.8	0.000				
38	6140.8	0.000	1112.1	0.000	495.2	0.000	139.4	0.000		
49	6262.6	0.000	1234.0	0.000	617.1	0.000	261.3	0.000	121.8	0.000
60	6342.2	0.000	1313.5	0.000	696.6	0.000	340.8	0.000	201.4	0.000

Building: Single-family City: NYC HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	105.6	0.000	224.4												
19	118.4	0.000	252.6	12.8	0.000	28.2									
30	125.9	0.000	268.8	20.3	0.000	44.4	7.5	0.000	16.2						
38	128.8	0.000	275.1	23.2	0.000	50.7	10.4	0.000	22.5	2.9	0.000	6.3			
49	131.4	0.000	280.7	25.8	0.000	56.3	13.0	0.000	28.2	5.5	0.000	11.9	2.6	0.000	5.6
60	133.1	0.000	284.3	27.5	0.000	59.9	14.7	0.000	31.7	7.2	0.000	15.5	4.3	0.000	9.2

Building: Single-family City: Syracuse HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	49.2	0.033	51.4												
13	57.2	0.033	59.6	8.0	0.000	8.2									
17	72.6	0.043	71.2	23.4	0.011	19.8	15.4	0.011	11.6						
19	74.9	0.043	75.4	25.7	0.011	24.1	17.7	0.011	15.8	2.3	0.000	4.2			
21	79.4	0.043	79.0	30.2	0.011	27.6	22.2	0.011	19.4	6.8	0.000	7.8	4.6	0.000	3.6
25	84.5	0.054	84.5	35.3	0.022	33.2	27.3	0.022	24.9	11.9	0.011	13.3	9.6	0.011	9.1
27	88.0	0.054	86.8	38.8	0.022	35.4	30.8	0.022	15.6	15.4	0.011	15.6	13.1	0.011	11.4

Building: Single-family City: Syracuse HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	760.8	0.033								
13	878.8	0.033	118.0	0.000						
17	1046.2	0.043	285.4	0.011	167.4	0.011				
19	1105.9	0.043	345.1	0.011	227.1	0.011	59.7	0.000		
21	1154.8	0.043	394.0	0.011	276.0	0.011	108.6	0.000	48.9	0.000
25	1233.0	0.054	472.3	0.022	354.2	0.022	186.9	0.011	127.1	0.011
27	1265.8	0.054	505.0	0.022	219.6	0.022	219.6	0.011	159.9	0.011

Building: Single-family City: Syracuse HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1175.9	0.033								
13	1363.4	0.033	187.5	0.000						
17	1631.7	0.043	455.8	0.011	268.3	0.011				
19	1726.3	0.043	550.4	0.011	362.9	0.011	94.6	0.000		
21	1807.7	0.043	631.8	0.011	444.3	0.011	176.0	0.000	81.4	0.000
25	1933.8	0.054	757.9	0.022	570.3	0.022	302.1	0.011	207.5	0.011
27	1985.6	0.054	809.7	0.022	622.2	0.022	353.9	0.011	259.3	0.011

Building: Single-family **City: Syracuse** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1151.6	0.000								
13	1335.1	0.000	183.5	0.000						
17	1593.5	0.000	441.9	0.000	258.4	0.000				
19	1688.1	0.000	536.4	0.000	352.9	0.000	94.5	0.000		
21	1766.6	0.000	615.0	0.000	431.5	0.000	173.1	0.000	78.6	0.000
25	1890.3	0.000	738.7	0.000	555.2	0.000	296.8	0.000	202.3	0.000
27	1939.7	0.000	788.1	0.000	604.6	0.000	346.2	0.000	251.7	0.000

Building: Single-family **City: Syracuse** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	25.0	0.000	51.5												
13	29.0	0.000	59.6	4.0	0.000	8.1									
17	34.7	0.000	71.3	9.6	0.000	19.8	5.6	0.000	11.7						
19	36.7	0.000	75.5	11.7	0.000	24.1	7.7	0.000	15.9	2.1	0.000	4.2			
21	38.4	0.000	79.1	13.3	0.000	27.6	9.3	0.000	19.5	3.7	0.000	7.8	1.6	0.000	3.6
25	41.1	0.000	84.7	16.0	0.000	33.2	12.0	0.000	25.0	6.4	0.000	13.3	4.3	0.000	9.1
27	42.2	0.000	86.8	17.1	0.000	35.3	13.1	0.000	27.2	7.5	0.000	15.5	5.4	0.000	11.3

Building: Single-family **City: Syracuse** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	344.0	0.188	318.9												
19	384.3	0.205	357.8	40.3	0.017	38.9									
30	406.0	0.222	380.7	61.9	0.034	61.8	21.7	0.017	22.9						
38	416.4	0.239	389.8	72.4	0.051	70.8	32.1	0.034	31.9	10.4	0.017	9.0			
49	420.6	0.239	397.6	76.6	0.051	78.7	36.3	0.034	39.8	14.7	0.017	16.9	4.3	0.000	7.8
60	426.3	0.239	402.7	82.3	0.051	83.8	42.0	0.034	44.9	20.3	0.017	22.0	9.9	0.000	13.0

Building: Single-family **City:** Syracuse **HVAC:** Heat Pump **Measure:** Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5539.8	0.188								
19	6144.0	0.205	604.3	0.017						
30	6488.6	0.222	948.8	0.034	344.5	0.017				
38	6621.2	0.239	1081.4	0.051	477.1	0.034	132.6	0.017		
49	6737.4	0.239	1197.6	0.051	593.3	0.034	248.8	0.017	116.2	0.000
60	6813.0	0.256	1273.2	0.068	668.9	0.051	324.4	0.034	191.8	0.017

Building: Single-family **City:** Syracuse **HVAC:** AC with Electric Heat **Measure:** Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7544.0	0.188								
19	8444.2	0.205	900.2	0.017						
30	8970.3	0.222	1426.3	0.034	526.1	0.017				
38	9178.5	0.239	1634.5	0.051	734.3	0.034	208.2	0.017		
49	9355.3	0.239	1811.3	0.051	911.1	0.034	385.0	0.017	176.8	0.000
60	9473.7	0.239	1929.7	0.051	1029.5	0.034	503.4	0.017	295.2	0.000

Building: Single-family **City:** Syracuse **HVAC:** Electric Heat, no AC **Measure:** Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7354.6	0.000								
19	8232.6	0.000	878.0	0.000						
30	8747.6	0.000	1393.0	0.000	515.0	0.000				
38	8949.5	0.000	1594.9	0.000	716.9	0.000	201.9	0.000		
49	9125.8	0.000	1771.2	0.000	893.2	0.000	378.2	0.000	176.3	0.000
60	9241.0	0.000	1886.3	0.000	1008.4	0.000	493.3	0.000	291.5	0.000

Building: Single-family **City:** Syracuse **HVAC:** Gas Heat No AC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	154.4	0.000	318.9												
19	172.7	0.000	357.8	18.3	0.000	38.9									
30	183.3	0.000	380.7	28.8	0.000	61.8	10.6	0.000	22.9						
38	187.4	0.000	389.8	32.9	0.000	70.8	14.7	0.000	31.9	4.1	0.000	9.0			
49	191.1	0.000	397.6	36.7	0.000	78.7	18.4	0.000	39.8	7.8	0.000	16.9	3.8	0.000	7.8
60	193.5	0.000	402.7	39.1	0.000	83.8	20.8	0.000	44.9	10.2	0.000	22.0	6.1	0.000	13.0

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

0			11			13			17			19		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
46.2	0.043	54.0												
54.3	0.054	62.6	8.1	0.011	8.7									
64.3	0.065	74.8	18.1	0.022	20.8	10.0	0.011	12.1						
67.4	0.065	79.2	21.2	0.022	25.3	13.1	0.011	16.6	3.1	0.000	4.4			
71.0	0.076	82.9	24.8	0.033	28.9	16.7	0.022	20.3	6.7	0.011	8.1	3.6	0.011	3.7
75.4	0.076	88.7	29.3	0.033	34.7	21.1	0.022	26.0	11.2	0.011	13.9	8.0	0.011	9.4
77.5	0.076	90.9	31.3	0.033	37.0	23.2	0.022	16.2	13.2	0.011	16.2	10.1	0.011	11.7

Single-family **City: Binghamton** **HVAC: Heat Pump** **Measure: Wall Insulation**

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

Single-family **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

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

Single-family **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

0		11		13		17		19	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
1222.6	0.000								
1417.4	0.000	194.8	0.000						
1691.4	0.000	468.8	0.000	274.0	0.000				
1791.5	0.000	568.8	0.000	374.1	0.000	100.0	0.000		
1874.9	0.000	652.3	0.000	457.5	0.000	183.5	0.000	83.5	0.000
2004.4	0.000	781.8	0.000	587.0	0.000	313.0	0.000	213.0	0.000
2055.6	0.000	833.0	0.000	638.2	0.000	364.2	0.000	264.1	0.000

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

0			11			13			17			19		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
27.3	0.000	54.0												
31.8	0.000	62.6	4.4	0.000	8.7									
37.8	0.000	74.8	10.5	0.000	20.8	6.1	0.000	12.1						
40.1	0.000	79.2	12.8	0.000	25.3	8.3	0.000	16.6	2.3	0.000	4.4			
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
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
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

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

0			11			19			30			38		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
311.4	0.290	332.9												
350.9	0.341	374.4	39.4	0.051	41.5									
369.8	0.358	398.8	58.4	0.068	65.9	18.9	0.017	24.4						
377.1	0.375	408.2	65.7	0.085	75.3	26.3	0.034	33.8	7.3	0.017	9.4			
385.2	0.392	416.6	73.7	0.102	83.6	34.3	0.051	42.2	15.4	0.034	17.7	8.0	0.017	8.4
389.4	0.392	422.0	78.0	0.102	89.1	38.6	0.051	47.6	19.6	0.034	23.2	12.3	0.017	13.8

Single-family **City: Binghamton** **HVAC: Heat Pump** **Measure: Roof Insulation**

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

Single-family **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Roof Insulation**

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

Single-family **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Roof Insulation**

0		11		19		30		38	
kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
7775.8	0.000								
8723.0	0.000	947.3	0.000						
9277.1	0.000	1501.4	0.000	554.1	0.000				
9493.9	0.000	1718.1	0.000	770.8	0.000	216.7	0.000		
9683.4	0.000	1907.7	0.000	960.4	0.000	406.3	0.000	189.6	0.000
9807.0	0.000	2031.2	0.000	1084.0	0.000	529.9	0.000	313.1	0.000

City: Binghamton **HVAC: Gas Heat No AC** **Measure: Roof Insulation**

0			11			19			30			38		
kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
166.0	0.000	333.1												
186.3	0.000	374.6	20.3	0.000	41.5									
198.1	0.000	398.8	32.1	0.000	65.7	11.8	0.000	24.2						
202.7	0.000	408.4	36.7	0.000	75.3	16.4	0.000	33.8	4.6	0.000	9.6			
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
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

Building: Single-family **City: Poughkeepsie** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	48.3	0.043	46.2												
13	53.4	0.054	53.8	5.1	0.011	7.6									
17	67.3	0.065	64.4	19.0	0.022	18.2	13.9	0.011	10.6						
19	71.0	0.065	68.3	22.7	0.022	22.1	17.6	0.011	14.5	3.7	0.000	3.9			
21	73.7	0.076	71.8	25.4	0.033	25.6	20.3	0.022	18.0	6.4	0.011	7.4	2.7	0.011	3.5
25	79.0	0.076	76.8	30.7	0.033	30.7	25.6	0.022	23.1	11.7	0.011	12.5	8.0	0.011	8.6
27	81.7	0.076	78.9	33.4	0.033	32.7	28.3	0.022	14.5	14.4	0.011	14.5	10.7	0.011	10.6

Building: **Single-family** **City: Poughkeepsie** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	591.6	0.054								
13	686.4	0.065	94.8	0.011						
17	823.1	0.076	231.5	0.022	136.7	0.011				
19	871.1	0.087	279.5	0.033	184.7	0.022	48.0	0.011		
21	914.8	0.087	323.2	0.033	228.4	0.022	91.7	0.011	43.7	0.000
25	978.4	0.098	386.8	0.043	292.0	0.033	155.3	0.022	107.3	0.011
27	1004.0	0.098	412.4	0.043	180.9	0.033	180.9	0.022	132.9	0.011

Building: **Single-family** **City: Poughkeepsie** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1031.3	0.043								
13	1197.2	0.054	165.8	0.011						
17	1435.7	0.065	404.4	0.022	238.6	0.011				
19	1521.5	0.065	490.1	0.022	324.3	0.011	85.7	0.000		
21	1597.1	0.076	565.8	0.033	400.0	0.022	161.4	0.011	75.7	0.011
25	1710.1	0.076	678.7	0.033	512.9	0.022	274.3	0.011	188.6	0.011
27	1755.9	0.076	724.6	0.033	558.7	0.022	320.2	0.011	234.4	0.011

Building: Single-family **City: Poughkeepsie** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1005.0	0.000								
13	1169.5	0.000	164.5	0.000						
17	1399.1	0.000	394.1	0.000	229.6	0.000				
19	1483.0	0.000	478.0	0.000	313.5	0.000	83.9	0.000		
21	1558.0	0.000	553.0	0.000	388.5	0.000	158.9	0.000	75.0	0.000
25	1667.5	0.000	662.5	0.000	497.9	0.000	268.4	0.000	184.5	0.000
27	1711.5	0.000	706.5	0.000	541.9	0.000	312.4	0.000	228.5	0.000

Building: Single-family **City: Poughkeepsie** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	21.8	0.000	46.3												
13	25.4	0.000	53.8	3.6	0.000	7.5									
17	30.2	0.000	64.5	8.5	0.000	18.2	4.9	0.000	10.7						
19	32.1	0.000	68.4	10.3	0.000	22.1	6.7	0.000	14.6	1.8	0.000	3.9			
21	33.7	0.000	71.9	11.9	0.000	25.6	8.3	0.000	18.1	3.5	0.000	7.4	1.6	0.000	3.5
25	36.1	0.000	77.0	14.3	0.000	30.7	10.7	0.000	23.2	5.9	0.000	12.5	4.0	0.000	8.6
27	37.0	0.000	79.0	15.2	0.000	32.7	11.6	0.000	25.3	6.7	0.000	14.5	4.9	0.000	10.6

Building: Single-family **City: Poughkeepsie** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	333.4	0.410	297.6												
19	374.6	0.461	335.5	41.1	0.051	37.9									
30	393.0	0.478	357.8	59.6	0.068	60.2	18.4	0.017	22.4						
38	402.7	0.495	366.7	69.3	0.085	69.1	28.2	0.034	31.2	9.7	0.017	8.9			
49	411.8	0.495	374.6	78.3	0.085	77.0	37.2	0.034	39.1	18.8	0.017	16.7	9.0	0.000	7.8
60	416.7	0.512	379.5	83.3	0.102	81.9	42.2	0.051	44.0	23.7	0.034	21.7	14.0	0.017	12.8

Building: Single-family City: Poughkeepsie HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4368.1	0.444								
19	4865.2	0.512	497.1	0.068						
30	5151.0	0.529	782.9	0.085	285.8	0.017				
38	5265.7	0.546	897.6	0.102	400.5	0.034	114.7	0.017		
49	5364.7	0.563	996.6	0.119	499.5	0.051	213.7	0.034	99.0	0.017
60	5427.1	0.563	1059.0	0.119	561.9	0.051	276.1	0.034	161.4	0.017

Building: Single-family City: Poughkeepsie HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6888.1	0.410								
19	7742.8	0.461	854.8	0.051						
30	8240.6	0.478	1352.6	0.068	497.8	0.017				
38	8439.1	0.495	1551.0	0.085	696.2	0.034	198.5	0.017		
49	8613.3	0.495	1725.3	0.085	870.5	0.034	372.7	0.017	174.2	0.000
60	8725.8	0.512	1837.7	0.102	982.9	0.051	485.2	0.034	286.7	0.017

Building: Single-family City: Poughkeepsie HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6694.7	0.000								
19	7526.8	0.000	832.1	0.000						
30	8017.2	0.000	1322.5	0.000	490.4	0.000				
38	8209.6	0.000	1514.8	0.000	682.8	0.000	192.3	0.000		
49	8376.8	0.000	1682.1	0.000	850.0	0.000	359.6	0.000	167.2	0.000
60	8486.9	0.000	1792.2	0.000	960.1	0.000	469.6	0.000	277.3	0.000

Building: Single-family City: Poughkeepsie HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	140.8	0.000	297.6												
19	158.4	0.000	335.5	17.6	0.000	37.9									
30	168.6	0.000	358.0	27.8	0.000	60.4	10.2	0.000	22.5						
38	172.5	0.000	366.7	31.7	0.000	69.1	14.2	0.000	31.2	3.9	0.000	8.7			
49	176.1	0.000	374.4	35.3	0.000	76.8	17.7	0.000	38.9	7.5	0.000	16.4	3.6	0.000	7.7
60	178.3	0.000	379.5	37.5	0.000	81.9	20.0	0.000	44.0	9.7	0.000	21.5	5.8	0.000	12.8

MULTI-FAMILY LOW-RISE INSULATION UPGRADES

Building: Multi-Family Low-rise City: Albany HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	44.5	0.046	61.0												
13	57.4	0.057	80.7	13.0	0.011	19.7									
17	77.2	0.069	108.7	32.7	0.023	47.7	19.7	0.011	28.0						
19	84.5	0.080	119.0	40.0	0.034	58.0	27.1	0.023	38.3	7.3	0.011	10.3			
21	87.9	0.080	128.0	43.5	0.034	67.0	30.5	0.023	47.2	10.8	0.011	19.3	3.4	0.000	8.9
25	99.0	0.092	141.7	54.5	0.046	80.7	41.5	0.034	61.0	21.8	0.023	33.0	14.4	0.011	22.7
27	100.9	0.092	147.2	56.4	0.046	86.2	43.5	0.034	66.5	23.7	0.023	38.5	16.4	0.011	28.2

Building: Multi-Family Low-rise City: Albany HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	764.5	0.000								
13	1010.1	0.011	245.6	0.000						
17	1348.0	0.034	583.5	0.023	337.9	0.000				
19	1472.4	0.034	707.9	0.023	462.3	0.000	124.4	0.000		
21	1577.3	0.034	812.9	0.023	567.3	0.000	229.3	0.000	104.9	0.000
25	1743.4	0.046	978.9	0.034	733.3	0.011	395.4	0.011	271.0	0.000
27	1809.9	0.046	1045.4	0.034	799.8	0.011	461.9	0.011	337.5	0.000

Building: Multi-Family Low-rise City: Albany HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	989.8	0.000								
13	1301.1	0.011	311.3	0.000						
17	1740.6	0.023	750.8	0.011	439.5	0.000				
19	1901.3	0.034	911.5	0.023	600.2	0.011	160.6	0.000		
21	2032.9	0.034	1043.1	0.023	731.8	0.011	292.3	0.000	131.6	0.000
25	2245.8	0.046	1256.0	0.034	944.7	0.023	505.2	0.011	344.6	0.000
27	2328.6	0.046	1338.8	0.034	1027.5	0.023	588.0	0.011	427.4	0.000

Building: Multi-Family Low-rise City: Albany HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	980.4	0.000								
13	1289.9	0.000	309.5	0.000						
17	1724.5	0.000	744.1	0.000	434.6	0.000				
19	1883.4	0.000	903.0	0.000	593.5	0.000	158.9	0.000		
21	2015.5	0.000	1035.1	0.000	725.6	0.000	291.0	0.000	132.1	0.000
25	2226.0	0.000	1245.6	0.000	936.1	0.000	501.5	0.000	342.6	0.000
27	2309.6	0.000	1329.2	0.000	1019.7	0.000	585.1	0.000	426.2	0.000

Building: Multi-Family Low-rise City: Albany HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	35.1	0.000	61.0												
13	46.2	0.000	80.7	11.1	0.000	19.7									
17	60.9	0.000	108.7	25.8	0.000	47.7	14.7	0.000	28.0						
19	66.5	0.000	119.0	31.4	0.000	58.0	20.3	0.000	38.3	5.6	0.000	10.3			
21	70.4	0.000	128.0	35.3	0.000	67.0	24.2	0.000	47.2	9.5	0.000	19.3	3.9	0.000	8.9
25	79.3	0.000	141.7	44.3	0.000	80.7	33.1	0.000	61.0	18.5	0.000	33.0	12.8	0.000	22.7
27	82.1	0.000	147.2	47.0	0.000	86.2	35.9	0.000	66.5	21.2	0.000	38.5	15.6	0.000	28.2

Building: Multi-Family Low-rise City: Albany HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	344.6	0.351	253.9												
19	406.0	0.413	301.5	61.3	0.061	47.6									
30	443.0	0.448	332.1	98.4	0.097	78.2	37.1	0.035	30.6						
38	459.5	0.466	344.5	114.8	0.114	90.6	53.5	0.053	43.0	16.4	0.018	12.4			
49	473.2	0.483	355.8	128.5	0.132	101.9	67.2	0.070	54.3	30.1	0.035	23.7	13.7	0.018	11.3
60	481.1	0.492	363.2	136.4	0.141	109.3	75.1	0.079	61.7	38.0	0.044	31.1	21.6	0.026	18.7

Building: Multi-Family Low-rise City: Albany HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4386.5	0.343								
19	5086.8	0.404	700.3	0.061						
30	5517.8	0.439	1131.3	0.097	431.0	0.035				
38	5694.0	0.448	1307.6	0.105	607.2	0.044	176.2	0.009		
49	5849.7	0.466	1463.2	0.123	762.9	0.061	331.9	0.026	155.7	0.018
60	5952.4	0.474	1565.9	0.132	865.6	0.070	434.6	0.035	258.4	0.026

Building: Multi-Family Low-rise City: Albany HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5034.2	0.351								
19	5883.8	0.413	849.6	0.061						
30	6408.2	0.448	1374.0	0.097	524.4	0.035				
38	6620.8	0.466	1586.6	0.114	737.0	0.053	212.6	0.018		
49	6809.0	0.483	1774.8	0.132	925.2	0.070	400.9	0.035	188.3	0.018
60	6933.1	0.492	1899.0	0.141	1049.4	0.079	525.0	0.044	312.4	0.026

Building: Multi-Family Low-rise City: Albany HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4849.7	0.000								
19	5667.1	0.000	817.4	0.000						
30	6173.5	0.000	1323.8	0.000	506.4	0.000				
38	6375.7	0.000	1526.0	0.000	708.6	0.000	202.2	0.000		
49	6558.3	0.000	1708.6	0.000	891.2	0.000	384.8	0.000	182.6	0.000
60	6678.5	0.000	1828.8	0.000	1011.3	0.000	505.0	0.000	302.7	0.000

Building: Multi-Family Low-rise City: Albany HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	160.2	0.000	253.9												
19	189.3	0.000	301.5	29.2	0.000	47.6									
30	208.4	0.000	332.1	48.2	0.000	78.2	19.1	0.000	30.6						
38	214.5	0.000	344.5	54.4	0.000	90.6	25.2	0.000	43.0	6.1	0.000	12.4			
49	222.4	0.000	355.8	62.3	0.000	101.9	33.1	0.000	54.3	14.1	0.000	23.7	7.9	0.000	11.3
60	226.5	0.000	363.2	66.3	0.000	109.3	37.2	0.000	61.7	18.1	0.000	31.1	11.9	0.000	18.7

Building: Multi-Family Low-rise City: Buffalo HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	35.3	0.023	61.7												
13	48.8	0.023	81.0	13.5	0.000	19.3									
17	62.5	0.034	107.7	27.2	0.011	46.0	13.6	0.011	26.7						
19	67.7	0.034	117.5	32.3	0.011	55.8	18.8	0.011	36.6	5.2	0.000	9.9			
21	72.6	0.046	125.8	37.3	0.023	64.1	23.7	0.023	44.8	10.1	0.011	18.1	4.9	0.011	8.3
25	80.5	0.046	139.1	45.2	0.023	77.4	31.6	0.023	58.1	18.0	0.011	31.4	12.8	0.011	21.6
27	83.7	0.046	144.5	48.4	0.023	82.8	34.9	0.023	63.5	21.2	0.011	36.8	16.1	0.011	26.9

Building: Multi-Family Low-rise City: Buffalo HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	760.8	0.000								
13	1005.4	0.000	244.6	0.000						
17	1336.9	0.011	576.1	0.011	331.5	0.000				
19	1457.6	0.011	696.8	0.011	452.2	0.000	120.7	0.000		
21	1557.4	0.011	796.6	0.011	552.0	0.000	220.5	0.000	99.8	0.000
25	1716.5	0.023	955.7	0.023	711.2	0.011	379.7	0.011	258.9	0.000
27	1781.2	0.023	1020.4	0.023	775.8	0.011	444.3	0.011	323.6	0.000

Building: Multi-Family Low-rise City: Buffalo HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	964.0	0.000								
13	1275.2	0.000	311.2	0.000						
17	1698.2	0.011	734.2	0.011	423.0	0.000				
19	1852.5	0.011	888.5	0.011	577.3	0.000	154.3	0.000		
21	1982.3	0.023	1018.3	0.023	707.1	0.011	284.1	0.011	129.8	0.000
25	2187.0	0.023	1223.0	0.023	911.8	0.011	488.8	0.011	334.5	0.000
27	2268.8	0.023	1304.8	0.023	993.6	0.011	570.6	0.011	416.2	0.000

Building: Multi-Family Low-rise City: Buffalo HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	960.2	0.000								
13	1267.2	0.000	307.0	0.000						
17	1690.7	-0.023	730.5	-0.023	423.6	0.000				
19	1843.7	0.000	883.5	0.000	576.5	0.023	153.0	0.000		
21	1975.5	0.000	1015.3	0.000	708.3	0.023	284.7	0.000	131.8	0.000
25	2177.4	-0.023	1217.2	-0.023	910.2	0.000	486.6	-0.023	333.7	0.000
27	2260.1	0.000	1299.9	0.000	992.9	0.023	569.3	0.000	416.4	0.000

Building: Multi-Family Low-rise City: Buffalo HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	31.5	0.000	61.7												
13	40.8	0.000	81.0	9.3	0.000	19.3									
17	55.2	-0.023	107.7	23.6	-0.023	46.0	14.3	0.000	26.7						
19	58.7	0.000	117.5	27.2	0.000	55.8	17.9	0.023	36.6	3.6	0.000	9.9			
21	65.8	0.000	125.8	34.3	0.000	64.1	25.0	0.023	44.8	10.7	0.000	18.1	7.1	0.000	8.3
25	70.9	-0.023	139.1	39.3	-0.023	77.4	30.0	0.000	58.1	15.7	-0.023	31.4	12.2	0.000	21.6
27	74.9	0.000	144.5	43.3	0.000	82.8	34.1	0.023	63.5	19.7	0.000	36.8	16.2	0.000	26.9

Building: Multi-Family Low-rise City: Buffalo HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	283.9	0.193	255.7												
19	332.8	0.237	302.5	48.8	0.044	46.7									
30	364.2	0.246	332.2	80.3	0.053	76.4	31.5	0.009	29.7						
38	377.1	0.255	344.2	93.1	0.061	88.5	44.3	0.018	41.7	12.8	0.009	12.0			
49	387.5	0.272	354.8	103.6	0.079	99.1	54.7	0.035	52.4	23.3	0.026	22.7	10.5	0.018	10.6
60	394.8	0.272	361.9	110.9	0.079	106.2	62.0	0.035	59.5	30.6	0.026	29.8	17.7	0.018	17.7

Building: **Multi-Family Low-rise** **City: Buffalo** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4262.2	0.193								
19	4950.5	0.228	688.3	0.035						
30	5361.6	0.246	1099.4	0.053	411.1	0.018				
38	5525.9	0.246	1263.6	0.053	575.3	0.018	164.3	0.000		
49	5670.6	0.255	1408.4	0.061	720.1	0.026	309.1	0.009	144.8	0.009
60	5769.6	0.264	1507.3	0.070	819.0	0.035	408.0	0.018	243.7	0.018

Building: **Multi-Family Low-rise** **City: Buffalo** **HVAC: AC with Electric Heat** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5017.6	0.193								
19	5846.5	0.237	829.0	0.044						
30	6357.2	0.246	1339.6	0.053	510.7	0.009				
38	6562.5	0.255	1544.9	0.061	716.0	0.018	205.3	0.009		
49	6743.3	0.272	1725.7	0.079	896.8	0.035	386.1	0.026	180.8	0.018
60	6862.8	0.272	1845.2	0.079	1016.3	0.035	505.6	0.026	300.3	0.018

Building: **Multi-Family Low-rise** **City: Buffalo** **HVAC: Electric Heat, no AC** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4884.2	0.000								
19	5690.2	-0.044	806.0	0.000						
30	6186.5	-0.018	1302.3	0.026	496.3	0.000				
38	6385.3	-0.018	1501.1	0.026	695.1	0.000	198.8	0.000		
49	6561.2	-0.018	1677.0	0.026	870.9	0.000	374.7	0.000	175.9	0.000
60	6677.4	-0.018	1793.2	0.026	987.2	0.000	490.9	0.000	292.1	0.000

Building: Multi-Family Low-rise **City: Buffalo** **HVAC: Gas Heat No AC** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	150.6	0.000	255.7												
19	176.6	-0.044	302.5	26.0	0.000	46.7									
30	193.6	-0.018	332.2	43.0	0.026	76.4	17.0	0.000	29.7						
38	199.9	-0.018	344.2	49.3	0.026	88.5	23.3	0.000	41.7	6.2	0.000	12.0			
49	205.4	-0.018	354.8	54.8	0.026	99.1	28.8	0.000	52.4	11.8	0.000	22.7	5.5	0.000	10.6
60	209.4	-0.018	361.9	58.9	0.026	106.2	32.9	0.000	59.5	15.8	0.000	29.8	9.6	0.000	17.7

Building: Multi-Family Low-rise City: Messina HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	43.1	0.034	68.1												
13	56.8	0.046	90.7	13.6	0.011	22.6									
17	77.3	0.057	122.9	34.2	0.023	54.8	20.5	0.011	32.2						
19	83.0	0.069	134.6	39.9	0.034	66.5	26.3	0.023	43.9	5.7	0.011	11.7			
21	87.9	0.069	144.1	44.8	0.034	76.0	31.2	0.023	53.4	10.7	0.011	21.2	4.9	0.000	9.5
25	96.4	0.080	159.7	53.3	0.046	91.6	39.7	0.034	69.0	19.1	0.023	36.8	13.4	0.011	25.1
27	100.4	0.080	166.0	57.3	0.046	97.9	43.7	0.034	75.3	23.2	0.023	43.1	17.4	0.011	31.4

Building: Multi-Family Low-rise City: Messina HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	933.6	0.000								
13	1229.6	0.011	296.0	0.000						
17	1645.5	0.023	711.8	0.011	415.9	0.000				
19	1795.1	0.034	861.5	0.023	565.5	0.011	149.6	0.000		
21	1921.3	0.034	987.7	0.023	691.8	0.011	275.9	0.000	126.2	0.000
25	2118.2	0.046	1184.6	0.034	888.7	0.023	472.8	0.011	323.1	0.000
27	2195.4	0.046	1261.8	0.034	965.8	0.023	549.9	0.011	400.3	0.000

Building: Multi-Family Low-rise City: Messina HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1142.6	0.000								
13	1504.5	0.011	361.9	0.000						
17	2034.9	0.023	892.2	0.011	530.3	0.000				
19	2219.4	0.034	1076.7	0.023	714.8	0.011	184.5	0.000		
21	2373.1	0.034	1230.5	0.023	868.6	0.011	338.3	0.000	153.8	0.000
25	2616.9	0.046	1474.3	0.034	1112.4	0.023	582.0	0.011	397.5	0.000
27	2715.5	0.046	1572.9	0.034	1211.0	0.023	680.7	0.011	496.2	0.000

Building: Multi-Family Low-rise City: Messina HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1136.1	0.000								
13	1496.4	0.000	360.3	0.000						
17	2022.1	0.000	886.0	0.000	525.7	0.000				
19	2206.7	0.000	1070.6	0.000	710.4	0.000	184.6	0.000		
21	2362.3	0.000	1226.2	0.000	866.0	0.000	340.2	0.000	155.6	0.000
25	2604.1	0.000	1468.0	0.000	1107.7	0.000	581.9	0.000	397.3	0.000
27	2703.2	0.000	1567.1	0.000	1206.9	0.000	681.1	0.000	496.5	0.000

Building: Multi-Family Low-rise City: Messina HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	36.2	0.000	68.1												
13	48.2	0.000	90.7	11.9	0.000	22.6									
17	64.4	0.000	122.8	28.2	0.000	54.7	16.3	0.000	32.1						
19	70.6	0.000	134.5	34.4	0.000	66.4	22.5	0.000	43.8	6.2	0.000	11.7			
21	76.9	0.000	144.0	40.7	0.000	75.9	28.8	0.000	53.3	12.5	0.000	21.2	6.3	0.000	9.5
25	83.5	0.000	159.6	47.2	0.000	91.5	35.3	0.000	68.9	19.0	0.000	36.8	12.8	0.000	25.1
27	88.1	0.000	166.0	51.8	0.000	97.9	39.9	0.000	75.3	23.6	0.000	43.2	17.4	0.000	31.5

Building: Multi-Family Low-rise City: Messina HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	350.3	0.404	301.6												
19	414.3	0.466	357.2	64.0	0.061	55.6									
30	450.0	0.510	392.4	99.7	0.105	90.8	35.7	0.044	35.2						
38	466.7	0.527	406.7	116.4	0.123	105.2	52.4	0.061	49.5	16.7	0.018	14.3			
49	480.0	0.536	419.7	129.8	0.132	118.2	65.7	0.070	62.5	30.0	0.026	27.3	13.4	0.009	13.0
60	487.8	0.545	428.1	137.6	0.141	126.5	73.5	0.079	70.9	37.9	0.035	35.7	21.2	0.018	21.3

Building: Multi-Family Low-rise City: Messina HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5933.3	0.387								
19	6907.4	0.457	974.1	0.070						
30	7488.7	0.492	1555.4	0.105	581.3	0.035				
38	7715.0	0.501	1781.7	0.114	807.6	0.044	226.3	0.009		
49	7921.5	0.518	1988.1	0.132	1014.1	0.061	432.8	0.026	206.4	0.018
60	8056.0	0.527	2122.7	0.141	1148.6	0.070	567.3	0.035	341.0	0.026

Building: Multi-Family Low-rise City: Messina HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6004.7	0.404								
19	7014.4	0.466	1009.8	0.061						
30	7635.5	0.510	1630.9	0.105	621.1	0.044				
38	7887.7	0.527	1883.1	0.123	873.3	0.061	252.2	0.018		
49	8110.2	0.536	2105.5	0.132	1095.8	0.070	474.7	0.026	222.4	0.009
60	8255.6	0.545	2251.0	0.141	1241.2	0.079	620.1	0.035	367.9	0.018

Building: Multi-Family Low-rise City: Messina HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5829.0	0.000								
19	6806.8	-0.026	977.8	0.000						
30	7412.7	-0.044	1583.7	-0.018	605.9	0.000				
38	7655.7	-0.044	1826.7	-0.018	848.9	0.000	243.0	0.000		
49	7871.7	-0.044	2042.6	-0.018	1064.8	0.000	458.9	0.000	215.9	0.000
60	8014.6	-0.044	2185.5	-0.018	1207.8	0.000	601.9	0.000	358.9	0.000

Building: Multi-Family Low-rise City: Messina HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	174.8	0.000	301.6												
19	206.7	-0.026	357.2	31.9	0.000	55.6									
30	227.2	-0.044	392.4	52.4	-0.018	90.8	20.5	0.000	35.2						
38	234.7	-0.044	406.7	59.9	-0.018	105.2	28.0	0.000	49.5	7.6	0.000	14.3			
49	241.8	-0.044	419.7	66.9	-0.018	118.1	35.1	0.000	62.5	14.6	0.000	27.2	7.0	0.000	12.9
60	247.0	-0.044	428.1	72.2	-0.018	126.5	40.3	0.000	70.9	19.9	0.000	35.7	12.3	0.000	21.3

Building: Multi-Family Low-rise City: NYC HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	37.8	0.034	44.1												
13	51.6	0.046	59.1	13.8	0.011	14.9									
17	70.1	0.069	78.9	32.2	0.034	34.7	18.5	0.023	19.8						
19	75.2	0.069	86.0	37.4	0.034	41.9	23.6	0.023	26.9	5.2	0.000	7.1			
21	79.3	0.080	92.1	41.5	0.046	47.9	27.7	0.034	33.0	9.3	0.011	13.2	4.1	0.011	6.1
25	88.5	0.080	101.6	50.7	0.046	57.4	36.9	0.034	42.5	18.5	0.011	22.7	13.3	0.011	15.6
27	90.8	0.080	105.1	53.0	0.046	61.0	39.2	0.034	46.1	20.8	0.011	26.3	15.6	0.011	19.1

Building: Multi-Family Low-rise City: NYC HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	469.7	0.000								
13	618.2	0.011	148.5	0.000						
17	832.5	0.023	362.8	0.011	214.3	0.000				
19	908.6	0.023	438.9	0.011	290.4	0.000	76.1	0.000		
21	971.4	0.034	501.8	0.023	353.3	0.011	139.0	0.011	62.8	0.000
25	1070.9	0.034	601.2	0.023	452.7	0.011	238.4	0.011	162.3	0.000
27	1104.2	0.046	634.6	0.034	486.1	0.023	271.8	0.023	195.6	0.000

Building: Multi-Family Low-rise City: NYC HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	687.5	0.000								
13	905.2	0.011	217.6	0.000						
17	1210.0	0.034	522.4	0.023	304.8	0.000				
19	1319.6	0.034	632.0	0.023	414.4	0.000	109.6	0.000		
21	1411.0	0.046	723.4	0.034	505.8	0.011	201.0	0.011	91.4	0.000
25	1557.0	0.046	869.5	0.034	651.9	0.011	347.1	0.011	237.5	0.000
27	1603.8	0.046	916.3	0.034	698.7	0.011	393.9	0.011	284.3	0.000

Building: Multi-Family Low-rise City: NYC HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	673.1	0.000								
13	883.3	0.000	210.2	0.000						
17	1178.3	0.000	505.2	0.000	295.0	0.000				
19	1287.4	0.000	614.3	0.000	404.1	0.000	109.0	0.000		
21	1375.9	0.000	702.8	0.000	492.6	0.000	197.6	0.000	88.5	0.000
25	1518.4	0.000	845.3	0.000	635.1	0.000	340.1	0.000	231.1	0.000
27	1564.3	0.000	891.2	0.000	681.0	0.000	386.0	0.000	276.9	0.000

Building: Multi-Family Low-rise City: NYC HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	23.4	0.000	44.1												
13	29.6	0.000	59.1	6.2	0.000	14.9									
17	38.3	0.000	78.9	14.9	0.000	34.7	8.7	0.000	19.8						
19	42.8	0.000	86.0	19.4	0.000	41.9	13.2	0.000	26.9	4.5	0.000	7.1			
21	44.3	0.000	92.1	20.9	0.000	47.9	14.7	0.000	33.0	6.0	0.000	13.2	1.5	0.000	6.1
25	49.9	0.000	101.7	26.5	0.000	57.6	20.3	0.000	42.7	11.6	0.000	22.8	7.1	0.000	15.7
27	51.1	0.000	105.1	27.7	0.000	61.0	21.6	0.000	46.1	12.8	0.000	26.3	8.4	0.000	19.1

Building: Multi-Family Low-rise City: NYC HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	372.7	0.369	181.6												
19	436.9	0.430	214.3	64.2	0.061	32.7									
30	475.4	0.466	235.4	102.7	0.097	53.9	38.5	0.035	21.2						
38	491.4	0.483	243.9	118.8	0.114	62.3	54.6	0.053	29.6	16.1	0.018	8.4			
49	505.1	0.492	251.0	132.4	0.123	69.4	68.2	0.061	36.7	29.7	0.026	15.5	13.6	0.009	7.1
60	514.9	0.501	256.1	142.2	0.132	74.5	78.0	0.070	41.8	39.5	0.035	20.6	23.5	0.018	12.2

Building: Multi-Family Low-rise City: NYC HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	2594.7	0.351								
19	3016.6	0.413	421.9	0.061						
30	3275.1	0.448	680.5	0.097	258.5	0.035				
38	3379.9	0.466	785.2	0.114	363.3	0.053	104.7	0.018		
49	3472.5	0.474	877.8	0.123	455.9	0.061	197.3	0.026	92.6	0.009
60	3531.2	0.483	936.6	0.132	514.6	0.070	256.1	0.035	151.4	0.018

Building: Multi-Family Low-rise City: NYC HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3591.8	0.369								
19	4183.7	0.430	591.8	0.061						
30	4546.3	0.466	954.5	0.097	362.6	0.035				
38	4692.6	0.483	1100.8	0.114	508.9	0.053	146.3	0.018		
49	4822.2	0.492	1230.3	0.123	638.5	0.061	275.8	0.026	129.6	0.009
60	4908.4	0.501	1316.5	0.132	724.7	0.070	362.0	0.035	215.8	0.018

Building: Multi-Family Low-rise City: NYC HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3350.2	0.000								
19	3900.6	0.000	550.5	0.000						
30	4238.8	0.000	888.6	0.000	338.1	0.000				
38	4375.1	0.000	1024.9	0.000	474.5	0.000	136.3	0.000		
49	4495.1	0.000	1145.0	0.000	594.5	0.000	256.3	0.000	120.0	0.000
60	4574.6	0.000	1224.5	0.000	674.0	0.000	335.9	0.000	199.5	0.000

Building: Multi-Family Low-rise City: NYC HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	131.1	0.000	181.6												
19	153.9	0.000	214.3	22.8	0.000	32.7									
30	167.7	0.000	235.4	36.6	0.000	53.9	13.8	0.000	21.2						
38	173.9	0.000	243.9	42.9	0.000	62.3	20.0	0.000	29.6	6.2	0.000	8.4			
49	178.1	0.000	251.0	47.0	0.000	69.4	24.2	0.000	36.7	10.4	0.000	15.5	4.1	0.000	7.1
60	181.3	0.000	256.1	50.3	0.000	74.5	27.4	0.000	41.8	13.6	0.000	20.6	7.4	0.000	12.2

Building: Multi-Family Low-rise City: Syracuse HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	44.8	0.034	61.3												
13	60.0	0.057	80.8	15.1	0.023	19.5									
17	79.1	0.069	108.5	34.3	0.034	47.1	19.1	0.011	27.6						
19	87.6	0.080	118.7	42.8	0.046	57.3	27.6	0.023	37.8	8.5	0.011	10.2			
21	93.7	0.092	127.5	48.8	0.057	66.2	33.7	0.034	46.7	14.6	0.023	19.0	6.1	0.011	8.8
25	103.4	0.092	140.9	58.6	0.057	79.6	43.5	0.034	60.1	24.3	0.023	32.5	15.8	0.011	22.2
27	106.9	0.103	146.5	62.0	0.069	85.2	46.9	0.046	65.7	27.7	0.034	38.1	19.3	0.023	27.9

Building: Multi-Family Low-rise City: Syracuse HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	785.3	0.000								
13	1030.8	0.011	245.5	0.000						
17	1380.9	0.034	595.6	0.023	350.1	0.000				
19	1506.7	0.046	721.4	0.034	475.9	0.011	125.8	0.000		
21	1613.9	0.046	828.6	0.034	583.1	0.011	233.0	0.000	107.2	0.000
25	1780.3	0.057	995.0	0.046	749.5	0.023	399.4	0.011	273.6	0.000
27	1847.5	0.057	1062.1	0.046	816.6	0.023	466.6	0.011	340.8	0.000

Building: Multi-Family Low-rise City: Syracuse HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1009.1	0.000								
13	1328.2	0.023	319.1	0.000						
17	1775.4	0.034	766.3	0.011	447.2	0.000				
19	1940.4	0.046	931.3	0.023	612.2	0.011	165.0	0.000		
21	2078.0	0.057	1068.9	0.034	749.8	0.023	302.6	0.011	137.6	0.000
25	2294.2	0.057	1285.2	0.034	966.1	0.023	518.9	0.011	353.9	0.000
27	2380.3	0.069	1371.3	0.046	1052.2	0.034	605.0	0.023	440.0	0.000

Building: Multi-Family Low-rise City: Syracuse HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1002.1	0.000								
13	1316.7	0.000	314.6	0.000						
17	1762.6	0.000	760.6	0.000	445.9	0.000				
19	1924.7	0.000	922.6	0.000	608.0	0.000	162.0	0.000		
21	2062.4	-0.023	1060.3	-0.023	745.7	-0.023	299.7	-0.023	137.7	0.000
25	2277.6	0.000	1275.5	0.000	960.9	0.000	515.0	0.000	352.9	0.000
27	2363.4	0.000	1361.3	0.000	1046.7	0.000	600.7	0.000	438.7	0.000

Building: Multi-Family Low-rise City: Syracuse HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	38.0	0.000	61.3												
13	48.4	0.000	80.8	10.4	0.000	19.5									
17	66.3	0.000	108.5	28.3	0.000	47.1	17.9	0.000	27.6						
19	71.9	0.000	118.7	33.9	0.000	57.3	23.5	0.000	37.8	5.6	0.000	10.2			
21	78.0	-0.023	127.5	40.0	-0.023	66.2	29.6	-0.023	46.7	11.7	-0.023	19.0	6.1	0.000	8.8
25	86.7	0.000	140.9	48.7	0.000	79.6	38.3	0.000	60.1	20.4	0.000	32.5	14.8	0.000	22.2
27	89.9	0.000	146.5	51.9	0.000	85.2	41.5	0.000	65.7	23.6	0.000	38.1	18.0	0.000	27.9

Building: Multi-Family Low-rise City: Syracuse HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	351.8	0.290	248.3												
19	414.0	0.351	294.7	62.1	0.061	46.5									
30	454.5	0.395	324.4	102.7	0.105	76.2	40.6	0.044	29.7						
38	470.3	0.413	337.3	118.4	0.123	89.0	56.3	0.061	42.5	15.7	0.018	12.8			
49	485.1	0.430	348.6	133.3	0.141	100.3	71.2	0.079	53.9	30.6	0.035	24.2	14.8	0.018	11.3
60	494.8	0.439	356.7	142.9	0.149	108.4	80.8	0.088	61.9	40.2	0.044	32.2	24.5	0.026	19.4

Building: Multi-Family Low-rise City: Syracuse HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4182.6	0.290								
19	4851.0	0.351	668.4	0.061						
30	5270.0	0.387	1087.3	0.097	419.0	0.035				
38	5441.1	0.404	1258.5	0.114	590.1	0.053	171.1	0.018		
49	5593.8	0.422	1411.1	0.132	742.8	0.070	323.8	0.035	152.7	0.018
60	5693.9	0.430	1511.3	0.141	842.9	0.079	424.0	0.044	252.8	0.026

Building: Multi-Family Low-rise City: Syracuse HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4874.3	0.290								
19	5701.5	0.351	827.2	0.061						
30	6220.2	0.395	1345.9	0.105	518.7	0.044				
38	6431.1	0.413	1556.8	0.123	729.6	0.061	210.9	0.018		
49	6620.7	0.430	1746.4	0.141	919.2	0.079	400.5	0.035	189.6	0.018
60	6745.7	0.439	1871.4	0.149	1044.2	0.088	525.5	0.044	314.6	0.026

Building: Multi-Family Low-rise City: Syracuse HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4685.6	0.000								
19	5480.2	-0.044	794.6	0.000						
30	5977.4	-0.044	1291.8	0.000	497.2	0.000				
38	6181.4	-0.061	1495.8	-0.018	701.2	-0.018	204.0	0.000		
49	6362.0	-0.061	1676.4	-0.018	881.8	-0.018	384.6	0.000	180.6	0.000
60	6481.5	-0.061	1795.9	-0.018	1001.3	-0.018	504.1	0.000	300.1	0.000

Building: Multi-Family Low-rise City: Syracuse HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	163.3	0.000	248.3												
19	192.7	-0.044	294.7	29.4	0.000	46.5									
30	211.9	-0.044	324.4	48.6	0.000	76.2	19.2	0.000	29.7						
38	220.7	-0.061	337.3	57.4	-0.018	89.0	27.9	-0.018	42.5	8.8	0.000	12.8			
49	226.7	-0.061	348.6	63.3	-0.018	100.3	33.9	-0.018	53.9	14.8	0.000	24.2	6.0	0.000	11.3
60	230.7	-0.061	356.7	67.4	-0.018	108.4	38.0	-0.018	61.9	18.8	0.000	32.2	10.0	0.000	19.4

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	41.6	0.023	62.8												
13	55.7	0.034	82.8	14.1	0.011	20.0									
17	73.2	0.046	112.0	31.5	0.023	49.2	17.4	0.011	29.2						
19	80.7	0.046	122.7	39.1	0.023	59.9	25.0	0.011	39.9	7.6	0.000	10.7			
21	87.5	0.046	132.1	45.9	0.023	69.3	31.8	0.011	49.3	14.3	0.000	20.1	6.8	0.000	9.4
25	96.2	0.057	146.5	54.6	0.034	83.7	40.5	0.023	63.8	23.0	0.011	34.5	15.5	0.011	23.9
27	99.8	0.057	152.2	58.1	0.034	89.3	44.0	0.023	69.4	26.6	0.011	40.1	19.0	0.011	29.5

Building: **Multi-Family Low-rise** **City: Binghamton** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	791.9	0.000								
13	1040.8	0.011	248.9	0.000						
17	1395.4	0.023	603.5	0.011	354.5	0.000				
19	1524.5	0.023	732.6	0.011	483.7	0.000	129.1	0.000		
21	1633.2	0.023	841.3	0.011	592.4	0.000	237.8	0.000	108.7	0.000
25	1802.5	0.034	1010.7	0.023	761.7	0.011	407.2	0.011	278.1	0.000
27	1869.7	0.034	1077.9	0.023	828.9	0.011	474.4	0.011	345.3	0.000

Building: **Multi-Family Low-rise** **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1019.7	0.000								
13	1341.6	0.011	321.9	0.000						
17	1793.1	0.023	773.4	0.011	451.6	0.000				
19	1960.3	0.023	940.6	0.011	618.7	0.000	167.2	0.000		
21	2101.1	0.023	1081.4	0.011	759.5	0.000	308.0	0.000	140.8	0.000
25	2319.2	0.034	1299.5	0.023	977.6	0.011	526.1	0.011	358.9	0.000
27	2406.7	0.034	1387.0	0.023	1065.1	0.011	613.6	0.011	446.4	0.000

Building: Multi-Family Low-rise City: Binghamton HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1014.6	0.000								
13	1333.0	0.000	318.4	0.000						
17	1785.0	0.011	770.4	0.011	452.0	0.000				
19	1950.6	0.011	936.0	0.011	617.6	0.000	165.6	0.000		
21	2089.0	0.011	1074.4	0.011	756.0	0.000	304.0	0.000	138.4	0.000
25	2307.5	0.023	1293.0	0.023	974.5	0.011	522.5	0.011	357.0	0.000
27	2394.3	0.023	1379.8	0.023	1061.3	0.011	609.3	0.011	443.8	0.000

Building: Multi-Family Low-rise City: Binghamton HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	36.6	0.000	62.8												
13	47.1	0.000	82.8	10.5	0.000	20.0									
17	64.9	0.011	112.0	28.3	0.011	49.2	17.8	0.000	29.2						
19	71.2	0.011	122.7	34.6	0.011	59.9	24.1	0.000	39.9	6.3	0.000	10.7			
21	75.2	0.011	132.1	38.6	0.011	69.3	28.1	0.000	49.3	10.3	0.000	20.1	4.0	0.000	9.4
25	84.5	0.023	146.4	47.9	0.023	83.6	37.4	0.011	63.6	19.6	0.011	34.4	13.3	0.000	23.7
27	87.3	0.023	152.2	50.7	0.023	89.3	40.1	0.011	69.4	22.4	0.011	40.1	16.1	0.000	29.5

Building: Multi-Family Low-rise City: Binghamton HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	301.9	0.264	257.9												
19	356.6	0.307	306.3	54.7	0.044	48.4									
30	392.1	0.343	337.3	90.2	0.079	79.3	35.5	0.035	30.9						
38	404.6	0.351	350.3	102.7	0.088	92.4	48.0	0.044	44.0	12.5	0.009	13.1			
49	417.3	0.360	360.9	115.4	0.097	103.0	60.7	0.053	54.6	25.2	0.018	23.6	12.7	0.009	10.5
60	424.9	0.369	368.4	123.1	0.105	110.4	68.3	0.061	62.0	32.9	0.026	31.1	20.4	0.018	18.0

Building: **Multi-Family Low-rise** **City: Binghamton** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4382.6	0.255								
19	5099.3	0.299	716.7	0.044						
30	5544.9	0.334	1162.3	0.079	445.7	0.035				
38	5723.0	0.343	1340.4	0.088	623.7	0.044	178.1	0.009		
49	5881.2	0.351	1498.6	0.097	782.0	0.053	336.3	0.018	158.2	0.009
60	5987.4	0.360	1604.8	0.105	888.2	0.061	442.5	0.026	264.4	0.018

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: AC with Electric Heat** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5076.3	0.264								
19	5946.5	0.307	870.2	0.044						
30	6484.6	0.343	1408.2	0.079	538.1	0.035				
38	6698.7	0.351	1622.3	0.088	752.2	0.044	214.1	0.009		
49	6890.3	0.360	1813.9	0.097	943.8	0.053	405.7	0.018	191.6	0.009
60	7015.9	0.369	1939.6	0.105	1069.4	0.061	531.3	0.026	317.2	0.018

Building: **Multi-Family Low-rise** **City: Binghamton** **HVAC: Electric Heat, no AC** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4935.8	0.000								
19	5778.6	0.018	842.8	0.000						
30	6301.2	0.026	1365.5	0.009	522.6	0.000				
38	6510.2	0.026	1574.5	0.009	731.6	0.000	209.0	0.000		
49	6696.9	0.026	1761.1	0.009	918.3	0.000	395.7	0.000	186.7	0.000
60	6818.9	0.026	1883.1	0.009	1040.2	0.000	517.6	0.000	308.6	0.000

Building: Multi-Family Low-rise **City: Binghamton** **HVAC: Gas Heat No AC** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	161.2	0.000	257.9												
19	188.5	0.018	306.3	27.3	0.000	48.4									
30	208.6	0.026	337.3	47.4	0.009	79.3	20.1	0.000	30.9						
38	215.9	0.026	350.3	54.7	0.009	92.4	27.4	0.000	44.0	7.3	0.000	13.1			
49	223.8	0.026	360.9	62.5	0.009	103.0	35.2	0.000	54.6	15.1	0.000	23.6	7.8	0.000	10.5
60	227.8	0.026	368.4	66.6	0.009	110.4	39.3	0.000	62.0	19.2	0.000	31.1	11.9	0.000	18.0

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	39.4	0.023	61.6												
13	53.3	0.023	81.6	13.9	0.000	20.1									
17	69.3	0.046	110.9	29.8	0.023	49.3	15.9	0.023	29.2						
19	77.4	0.046	121.8	38.0	0.023	60.2	24.1	0.023	40.1	8.1	0.000	10.9			
21	82.7	0.046	130.7	43.2	0.023	69.1	29.4	0.023	49.1	13.4	0.000	19.8	5.3	0.000	8.9
25	91.5	0.057	145.3	52.1	0.034	83.7	38.2	0.034	63.6	22.2	0.011	34.4	14.1	0.011	23.5
27	94.8	0.057	151.1	55.4	0.034	89.6	41.5	0.034	69.5	25.6	0.011	40.2	17.4	0.011	29.4

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Heat Pump Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	663.6	0.000								
13	873.5	0.011	210.0	0.000						
17	1171.2	0.023	507.6	0.011	297.7	0.000				
19	1284.4	0.023	620.8	0.011	410.8	0.000	113.2	0.000		
21	1374.0	0.023	710.5	0.011	500.5	0.000	202.8	0.000	89.7	0.000
25	1519.1	0.034	855.5	0.023	645.6	0.011	347.9	0.011	234.7	0.000
27	1577.0	0.034	913.4	0.023	703.5	0.011	405.8	0.011	292.6	0.000

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	867.7	0.000								
13	1144.5	0.000	276.8	0.000						
17	1532.2	0.023	664.5	0.023	387.7	0.000				
19	1676.5	0.023	808.9	0.023	532.0	0.000	144.4	0.000		
21	1795.8	0.023	928.1	0.023	651.3	0.000	263.6	0.000	119.3	0.000
25	1984.6	0.034	1117.0	0.034	840.2	0.011	452.5	0.011	308.1	0.000
27	2060.1	0.034	1192.4	0.034	915.6	0.011	527.9	0.011	383.6	0.000

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	863.4	0.000								
13	1137.9	0.000	274.5	0.000						
17	1524.7	0.000	661.3	0.000	386.8	0.000				
19	1666.8	0.023	803.3	0.023	528.8	0.023	142.1	0.000		
21	1786.3	0.023	922.8	0.023	648.3	0.023	261.6	0.000	119.5	0.000
25	1974.8	0.000	1111.3	0.000	836.8	0.000	450.1	-0.023	308.0	0.000
27	2050.5	0.000	1187.0	0.000	912.5	0.000	525.7	-0.023	383.7	0.000

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Gas Heat, no AC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	35.4	0.000	61.6												
13	47.0	0.000	81.8	11.6	0.000	20.2									
17	62.1	0.000	110.9	26.7	0.000	49.3	15.1	0.000	29.1						
19	67.9	0.023	121.8	32.5	0.023	60.2	20.9	0.023	40.0	5.7	0.000	10.9			
21	73.4	0.023	130.6	38.0	0.023	69.0	26.4	0.023	48.8	11.2	0.000	19.7	5.5	0.000	8.8
25	81.8	0.000	145.3	46.3	0.000	83.7	34.7	0.000	63.5	19.6	-0.023	34.4	13.9	0.000	23.5
27	85.2	0.000	151.2	49.8	0.000	89.7	38.2	0.000	69.5	23.0	-0.023	40.4	17.3	0.000	29.5

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: AC with Gas Heat Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	357.2	0.343	246.5												
19	423.3	0.395	298.1	66.1	0.053	51.6									
30	464.6	0.430	332.0	107.4	0.088	85.5	41.3	0.035	33.9						
38	481.2	0.448	346.5	124.0	0.105	100.0	57.9	0.053	48.4	16.6	0.018	14.5			
49	495.7	0.457	359.4	138.5	0.114	112.9	72.5	0.061	61.3	31.2	0.026	27.4	14.6	0.009	12.9
60	504.6	0.466	368.1	147.4	0.123	121.6	81.3	0.070	70.0	40.1	0.035	36.1	23.5	0.018	21.6

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Heat Pump Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3838.4	0.334								
19	4496.7	0.387	658.4	0.053						
30	4908.8	0.422	1070.5	0.088	412.1	0.035				
38	5074.2	0.439	1235.9	0.105	577.5	0.053	165.4	0.018		
49	5221.4	0.448	1383.0	0.114	724.7	0.061	312.6	0.026	147.1	0.009
60	5317.8	0.448	1479.4	0.114	821.0	0.061	408.9	0.026	243.5	0.009

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: AC with Electric Heat Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4482.9	0.343								
19	5283.0	0.395	800.1	0.053						
30	5783.2	0.430	1300.3	0.088	500.2	0.035				
38	5985.8	0.448	1502.9	0.105	702.8	0.053	202.6	0.018		
49	6165.8	0.457	1682.9	0.114	882.8	0.061	382.6	0.026	180.0	0.009
60	6284.3	0.466	1801.4	0.123	1001.3	0.070	501.1	0.035	298.5	0.018

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Electric Heat, no AC Measure: Roof Insulation

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	4298.9	0.000								
19	5064.3	-0.018	765.4	0.000						
30	5544.0	-0.018	1245.1	0.000	479.7	0.000				
38	5738.0	-0.018	1439.2	0.000	673.7	0.000	194.1	0.000		
49	5911.7	-0.018	1612.8	0.000	847.4	0.000	367.7	0.000	173.7	0.000
60	6026.6	-0.018	1727.8	0.000	962.3	0.000	482.6	0.000	288.6	0.000

Building: Multi-Family Low-rise City: Poughkeepsie HVAC: Gas Heat No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	173.1	0.000	246.5												
19	204.6	-0.018	298.1	31.5	0.000	51.6									
30	225.4	-0.018	332.0	52.4	0.000	85.5	20.8	0.000	33.9						
38	233.5	-0.018	346.5	60.4	0.000	100.0	28.9	0.000	48.4	8.1	0.000	14.5			
49	241.5	-0.018	359.5	68.4	0.000	113.0	36.9	0.000	61.4	16.1	0.000	27.5	8.0	0.000	13.0
60	246.8	-0.018	368.2	73.7	0.000	121.7	42.2	0.000	70.1	21.3	0.000	36.2	13.3	0.000	21.7

MULTI-FAMILY HIGH-RISE INSULATION UPGRADES

Building: Multi-Family High-rise **City:** Albany **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	14.6	0.008	51.3												
13	18.9	0.014	67.0	4.3	0.005	15.7									
17	24.7	0.016	88.9	10.1	0.008	37.5	5.8	0.003	21.8						
19	26.8	0.019	96.9	12.2	0.011	45.6	7.9	0.005	29.9	2.1	0.003	8.1			
21	28.5	0.022	103.6	13.9	0.014	52.2	9.6	0.008	36.5	3.8	0.005	14.7	1.7	0.003	6.6
25	31.0	0.022	113.5	16.3	0.014	62.2	12.0	0.008	46.5	6.2	0.005	24.7	4.2	0.003	16.6
27	32.0	0.024	117.6	17.4	0.016	66.3	13.1	0.011	50.6	7.3	0.008	28.7	5.2	0.005	20.7

Building: Multi-Family High-rise **City:** Albany **HVAC:** Chiller and Boiler with FPFC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	138.1	0.254	411.4												
19	150.5	0.263	476.4	12.4	0.009	65.0									
30	156.8	0.281	515.6	18.8	0.026	104.2	6.3	0.018	39.2						
38	159.1	0.281	531.1	21.0	0.026	119.7	8.6	0.018	54.7	2.3	0.000	15.5			
49	160.9	0.298	545.2	22.9	0.044	133.9	10.4	0.035	68.8	4.1	0.018	29.6	1.8	0.018	14.1
60	162.1	0.307	554.7	24.0	0.053	143.3	11.6	0.044	78.3	5.3	0.026	39.1	3.0	0.026	23.6

Building: Multi-Family High-rise **City:** Albany **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	57.2												
13	0.0	0.0	74.7	0.0	0.0	17.5									
17	0.0	0.0	99.0	0.0	0.0	41.8	0.0	0.0	24.3						
19	0.0	0.0	108.0	0.0	0.0	50.8	0.0	0.0	33.3	0.0	0.0	9.0			
21	0.0	0.0	115.4	0.0	0.0	58.2	0.0	0.0	40.7	0.0	0.0	16.4	0.0	0.0	7.4
25	0.0	0.0	126.5	0.0	0.0	69.3	0.0	0.0	51.8	0.0	0.0	27.5	0.0	0.0	18.5
27	0.0	0.0	131.1	0.0	0.0	73.9	0.0	0.0	56.4	0.0	0.0	32.0	0.0	0.0	23.1

Building: Multi-Family High-rise City: Albany HVAC: Steam Boiler Only Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	458.4												
19	0.0	0.0	530.9	0.0	0.0	72.5									
30	0.0	0.0	574.5	0.0	0.0	116.1	0.0	0.0	43.7						
38	0.0	0.0	591.8	0.0	0.0	133.4	0.0	0.0	60.9	0.0	0.0	17.3			
49	0.0	0.0	607.5	0.0	0.0	149.2	0.0	0.0	76.7	0.0	0.0	33.0	0.0	0.0	15.7
60	0.0	0.0	618.1	0.0	0.0	159.7	0.0	0.0	87.2	0.0	0.0	43.6	0.0	0.0	26.3

Building: Multi-Family High-rise City: Buffalo HVAC: Chiller and Boiler with FPFC Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	10.2	0.005	52.3												
13	13.2	0.008	68.8	3.0	0.003	16.5									
17	17.3	0.011	91.8	7.1	0.005	39.5	4.1	0.003	23.0						
19	18.7	0.011	100.0	8.5	0.005	47.7	5.5	0.003	31.2	1.4	0.000	8.2			
21	19.9	0.014	106.8	9.7	0.008	54.5	6.7	0.005	38.0	2.6	0.003	15.0	1.2	0.003	6.8
25	21.7	0.014	117.4	11.4	0.008	65.1	8.4	0.005	48.6	4.4	0.003	25.6	3.0	0.003	17.4
27	22.4	0.014	121.7	12.2	0.008	69.4	9.1	0.005	52.9	5.1	0.003	29.9	3.7	0.003	21.7

Building: Multi-Family High-rise City: Buffalo HVAC: Chiller and Boiler with FPFC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	110.0	0.079	406.5												
19	117.0	0.105	468.2	7.0	0.026	61.7									
30	120.1	0.123	506.7	10.1	0.044	100.3	3.1	0.018	38.6						
38	121.0	0.131	521.7	11.0	0.053	115.2	3.9	0.026	53.5	0.9	0.009	14.9			
49	121.7	0.131	535.6	11.7	0.053	129.1	4.6	0.026	67.4	1.6	0.009	28.8	0.7	0.000	13.9
60	122.1	0.140	544.5	12.1	0.061	138.1	5.1	0.035	76.3	2.0	0.018	37.8	1.1	0.009	22.9

Building: Multi-Family High-rise **City:** Buffalo **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	58.3												
13	0.0	0.0	76.7	0.0	0.0	18.4									
17	0.0	0.0	102.3	0.0	0.0	44.0	0.0	0.0	25.6						
19	0.0	0.0	111.4	0.0	0.0	53.1	0.0	0.0	34.8	0.0	0.0	9.1			
21	0.0	0.0	119.0	0.0	0.0	60.7	0.0	0.0	42.4	0.0	0.0	16.7	0.0	0.0	7.6
25	0.0	0.0	130.8	0.0	0.0	72.5	0.0	0.0	54.1	0.0	0.0	28.5	0.0	0.0	19.4
27	0.0	0.0	135.6	0.0	0.0	77.3	0.0	0.0	59.0	0.0	0.0	33.3	0.0	0.0	24.2

Building: Multi-Family High-rise **City:** Buffalo **HVAC:** Steam Boiler Only **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	452.9												
19	0.0	0.0	521.7	0.0	0.0	68.8									
30	0.0	0.0	564.7	0.0	0.0	111.7	0.0	0.0	43.0						
38	0.0	0.0	581.3	0.0	0.0	128.3	0.0	0.0	59.6	0.0	0.0	16.6			
49	0.0	0.0	596.8	0.0	0.0	143.9	0.0	0.0	75.1	0.0	0.0	32.1	0.0	0.0	15.5
60	0.0	0.0	606.8	0.0	0.0	153.8	0.0	0.0	85.1	0.0	0.0	42.1	0.0	0.0	25.5

Building: Multi-Family High-rise **City:** Massena **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	17.9	0.016	61.3												
13	23.2	0.024	80.3	5.3	0.008	19.0									
17	30.5	0.033	106.3	12.6	0.016	45.0	7.3	0.008	26.0						
19	33.1	0.035	115.6	15.2	0.019	54.3	9.9	0.011	35.3	2.6	0.003	9.4			
21	35.3	0.038	123.6	17.4	0.022	62.3	12.1	0.014	43.3	4.8	0.005	17.3	2.2	0.003	8.0
25	38.6	0.041	136.0	20.8	0.024	74.7	15.4	0.016	55.7	8.1	0.008	29.7	5.5	0.005	20.3
27	40.0	0.044	140.9	22.1	0.027	79.6	16.8	0.019	60.6	9.5	0.011	34.6	6.9	0.008	25.3

Building: Multi-Family High-rise **City:** Massena **HVAC:** Chiller and Boiler with FPFC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	130.3	0.149	481.9												
19	140.4	0.175	556.3	10.1	0.026	74.3									
30	145.5	0.193	601.4	15.2	0.044	119.5	5.1	0.018	45.1						
38	147.3	0.210	619.5	16.9	0.061	137.5	6.8	0.035	63.2	1.8	0.018	18.1			
49	148.8	0.219	635.5	18.4	0.070	153.6	8.3	0.044	79.2	3.2	0.026	34.1	1.5	0.009	16.0
60	149.5	0.228	645.7	19.2	0.079	163.7	9.1	0.053	89.4	4.0	0.035	44.3	2.3	0.018	26.2

Building: Multi-Family High-rise **City:** Massena **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	68.3												
13	0.0	0.0	89.5	0.0	0.0	21.2									
17	0.0	0.0	118.4	0.0	0.0	50.1	0.0	0.0	28.9						
19	0.0	0.0	128.9	0.0	0.0	60.5	0.0	0.0	39.4	0.0	0.0	10.4			
21	0.0	0.0	137.7	0.0	0.0	69.4	0.0	0.0	48.2	0.0	0.0	19.3	0.0	0.0	8.9
25	0.0	0.0	151.5	0.0	0.0	83.2	0.0	0.0	62.0	0.0	0.0	33.1	0.0	0.0	22.7
27	0.0	0.0	157.0	0.0	0.0	88.7	0.0	0.0	67.5	0.0	0.0	38.6	0.0	0.0	28.2

Building: Multi-Family High-rise **City:** Massena **HVAC:** Steam Boiler Only **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	537.0												
19	0.0	0.0	619.9	0.0	0.0	82.8									
30	0.0	0.0	670.2	0.0	0.0	133.1	0.0	0.0	50.3						
38	0.0	0.0	690.3	0.0	0.0	153.3	0.0	0.0	70.4	0.0	0.0	20.1			
49	0.0	0.0	708.1	0.0	0.0	171.1	0.0	0.0	88.3	0.0	0.0	38.0	0.0	0.0	17.9
60	0.0	0.0	719.5	0.0	0.0	182.5	0.0	0.0	99.6	0.0	0.0	49.3	0.0	0.0	29.2

Building: Multi-Family High-rise **City:** NYC **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	36.2	0.008	35.5												
13	47.2	0.011	46.2	11.0	0.003	10.7									
17	62.4	0.016	61.2	26.2	0.008	25.7	15.2	0.005	15.0						
19	67.9	0.016	66.5	31.7	0.008	30.9	20.6	0.005	20.3	5.5	0.000	5.2			
21	72.4	0.019	71.1	36.2	0.011	35.5	25.2	0.008	24.9	10.0	0.003	9.8	4.5	0.003	4.6
25	79.5	0.019	78.3	43.2	0.011	42.8	32.2	0.008	32.1	17.1	0.003	17.1	11.6	0.003	11.9
27	82.3	0.022	81.0	46.0	0.014	45.5	35.0	0.011	34.8	19.9	0.005	19.8	14.4	0.005	14.6

Building: Multi-Family High-rise **City:** NYC **HVAC:** Chiller and Boiler with FPFC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	279.9	0.114	285.9												
19	315.5	0.149	333.4	35.6	0.035	47.5									
30	335.8	0.175	361.7	55.9	0.061	75.8	20.3	0.026	28.3						
38	343.6	0.184	373.5	63.7	0.070	87.7	28.1	0.035	40.1	7.8	0.009	11.8			
49	350.4	0.193	382.9	70.5	0.079	97.0	34.9	0.044	49.5	14.6	0.018	21.2	6.7	0.009	9.4
60	354.8	0.202	390.3	74.9	0.088	104.4	39.3	0.053	56.9	18.9	0.026	28.6	11.1	0.018	16.7

Building: Multi-Family High-rise **City:** NYC **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	39.6												
13	0.0	0.0	51.5	0.0	0.0	11.9									
17	0.0	0.0	68.2	0.0	0.0	28.6	0.0	0.0	16.8						
19	0.0	0.0	74.1	0.0	0.0	34.5	0.0	0.0	22.6	0.0	0.0	5.8			
21	0.0	0.0	79.2	0.0	0.0	39.6	0.0	0.0	27.7	0.0	0.0	10.9	0.0	0.0	5.1
25	0.0	0.0	87.3	0.0	0.0	47.7	0.0	0.0	35.8	0.0	0.0	19.0	0.0	0.0	13.2
27	0.0	0.0	90.3	0.0	0.0	50.7	0.0	0.0	38.8	0.0	0.0	22.1	0.0	0.0	16.2

Building: Multi-Family High-rise **City:** NYC **HVAC:** Steam Boiler Only **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	318.5												
19	0.0	0.0	371.5	0.0	0.0	52.9									
30	0.0	0.0	403.0	0.0	0.0	84.5	0.0	0.0	31.5						
38	0.0	0.0	416.2	0.0	0.0	97.7	0.0	0.0	44.7	0.0	0.0	13.2			
49	0.0	0.0	426.6	0.0	0.0	108.1	0.0	0.0	55.2	0.0	0.0	23.6	0.0	0.0	10.5
60	0.0	0.0	434.9	0.0	0.0	116.3	0.0	0.0	63.4	0.0	0.0	31.8	0.0	0.0	18.7

Building: Multi-Family High-rise **City:** Syracuse **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	16.1	0.014	50.6												
13	20.9	0.019	66.1	4.8	0.005	15.5									
17	27.4	0.024	87.7	11.2	0.011	37.1	6.5	0.005	21.6						
19	29.6	0.027	95.5	13.5	0.014	44.9	8.8	0.008	29.4	2.3	0.003	7.8			
21	31.5	0.030	102.0	15.4	0.016	51.4	10.6	0.011	35.9	4.2	0.005	14.3	1.9	0.003	6.4
25	34.4	0.033	112.5	18.3	0.019	61.8	13.5	0.014	46.3	7.0	0.008	24.7	4.8	0.005	16.9
27	35.5	0.033	116.8	19.4	0.019	66.2	14.7	0.014	50.7	8.2	0.008	29.1	5.9	0.005	21.3

Building: Multi-Family High-rise **City:** Syracuse **HVAC:** Chiller and Boiler with FPFC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	153.8	0.289	403.0												
19	166.6	0.359	466.0	12.8	0.070	63.0									
30	172.8	0.403	503.8	18.9	0.114	100.8	6.1	0.044	37.8						
38	174.8	0.421	519.9	21.0	0.131	116.9	8.2	0.061	53.9	2.0	0.018	16.1			
49	176.5	0.447	534.9	22.6	0.158	131.9	9.8	0.088	68.9	3.7	0.044	31.1	1.7	0.026	15.0
60	177.5	0.456	543.7	23.7	0.167	140.7	10.9	0.096	77.7	4.7	0.053	39.9	2.7	0.035	23.8

Building: Multi-Family High-rise **City:** Syracuse **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	56.4												
13	0.0	0.0	73.7	0.0	0.0	17.3									
17	0.0	0.0	97.7	0.0	0.0	41.3	0.0	0.0	24.1						
19	0.0	0.0	106.5	0.0	0.0	50.1	0.0	0.0	32.8	0.0	0.0	8.7			
21	0.0	0.0	113.6	0.0	0.0	57.2	0.0	0.0	40.0	0.0	0.0	15.9	0.0	0.0	7.2
25	0.0	0.0	125.3	0.0	0.0	68.9	0.0	0.0	51.6	0.0	0.0	27.6	0.0	0.0	18.8
27	0.0	0.0	130.2	0.0	0.0	73.8	0.0	0.0	56.5	0.0	0.0	32.4	0.0	0.0	23.7

Building: Multi-Family High-rise **City:** Syracuse **HVAC:** Steam Boiler Only **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	449.0												
19	0.0	0.0	519.2	0.0	0.0	70.2									
30	0.0	0.0	561.3	0.0	0.0	112.3	0.0	0.0	42.1						
38	0.0	0.0	579.3	0.0	0.0	130.3	0.0	0.0	60.1	0.0	0.0	18.0			
49	0.0	0.0	596.0	0.0	0.0	147.0	0.0	0.0	76.8	0.0	0.0	34.7	0.0	0.0	16.7
60	0.0	0.0	605.8	0.0	0.0	156.8	0.0	0.0	86.5	0.0	0.0	44.4	0.0	0.0	26.5

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	9.7	0.005	55.6												
13	12.5	0.005	72.8	2.8	0.000	17.2									
17	16.2	0.008	96.9	6.4	0.003	41.3	3.7	0.003	24.1						
19	17.5	0.008	105.5	7.7	0.003	49.9	4.9	0.003	32.7	1.3	0.000	8.6			
21	18.5	0.011	112.7	8.7	0.005	57.1	6.0	0.005	39.9	2.3	0.003	15.8	1.0	0.003	7.2
25	20.0	0.011	123.8	10.3	0.005	68.2	7.5	0.005	51.0	3.9	0.003	26.9	2.6	0.003	18.3
27	20.6	0.011	128.4	10.9	0.005	72.8	8.1	0.005	55.6	4.5	0.003	31.5	3.2	0.003	22.9

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Chiller and Boiler with FPFC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	140.8	0.088	420.9												
19	152.9	0.096	489.0	12.1	0.009	68.1									
30	158.9	0.123	531.7	18.1	0.035	110.8	6.0	0.026	42.7						
38	161.0	0.131	548.0	20.2	0.044	127.1	8.2	0.035	59.0	2.1	0.009	16.3			
49	162.8	0.140	562.9	22.0	0.053	142.0	9.9	0.044	73.9	3.9	0.018	31.2	1.8	0.009	14.9
60	163.7	0.140	572.7	23.0	0.053	151.7	10.9	0.044	83.6	4.8	0.018	40.9	2.7	0.009	24.6

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	62.0												
13	0.0	0.0	81.1	0.0	0.0	19.2									
17	0.0	0.0	108.0	0.0	0.0	46.0	0.0	0.0	26.9						
19	0.0	0.0	117.6	0.0	0.0	55.6	0.0	0.0	36.4	0.0	0.0	9.6			
21	0.0	0.0	125.6	0.0	0.0	63.6	0.0	0.0	44.4	0.0	0.0	17.6	0.0	0.0	8.0
25	0.0	0.0	137.9	0.0	0.0	76.0	0.0	0.0	56.8	0.0	0.0	30.0	0.0	0.0	20.4
27	0.0	0.0	143.0	0.0	0.0	81.1	0.0	0.0	61.9	0.0	0.0	35.1	0.0	0.0	25.5

Building: Multi-Family High-rise **City:** Binghamton **HVAC:** Steam Boiler Only **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	469.0												
19	0.0	0.0	544.9	0.0	0.0	75.9									
30	0.0	0.0	592.5	0.0	0.0	123.5	0.0	0.0	47.6						
38	0.0	0.0	610.7	0.0	0.0	141.6	0.0	0.0	65.7	0.0	0.0	18.2			
49	0.0	0.0	627.3	0.0	0.0	158.2	0.0	0.0	82.3	0.0	0.0	34.8	0.0	0.0	16.6
60	0.0	0.0	638.1	0.0	0.0	169.1	0.0	0.0	93.2	0.0	0.0	45.6	0.0	0.0	27.4

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Chiller and Boiler with FPFC **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	12.6	0.008	40.5												
13	16.2	0.011	53.5	3.6	0.003	13.0									
17	20.9	0.014	71.9	8.3	0.005	31.4	4.7	0.003	18.4						
19	22.5	0.014	78.6	9.9	0.005	38.1	6.3	0.003	25.1	1.6	0.000	6.7			
21	23.8	0.016	83.8	11.2	0.008	43.4	7.6	0.005	30.3	2.9	0.003	11.9	1.3	0.003	5.2
25	25.7	0.016	92.0	13.1	0.008	51.5	9.5	0.005	38.5	4.8	0.003	20.1	3.2	0.003	13.4
27	26.5	0.016	95.1	13.9	0.008	54.6	10.3	0.005	41.6	5.6	0.003	23.2	4.0	0.003	16.5

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Chiller and Boiler with FPFC **Measure:** Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	107.4	0.105	393.0												
19	109.9	0.149	456.3	2.5	0.044	63.4									
30	109.7	0.167	495.1	2.3	0.061	102.1	-0.3	0.018	38.7						
38	109.0	0.175	512.0	1.6	0.070	119.0	-1.0	0.026	55.7	-0.7	0.009	16.9			
49	108.1	0.184	525.4	0.7	0.079	132.5	-1.8	0.035	69.1	-1.6	0.018	30.3	-0.9	0.009	13.4
60	107.3	0.193	533.8	-0.1	0.088	140.9	-2.6	0.044	77.5	-2.4	0.026	38.7	-1.7	0.018	21.8

Building: Multi-Family High-rise **City:** Poughkeepsie **HVAC:** Steam Boiler Only **Measure:** Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	45.1												
13	0.0	0.0	59.6	0.0	0.0	14.5									
17	0.0	0.0	80.1	0.0	0.0	35.0	0.0	0.0	20.5						
19	0.0	0.0	87.6	0.0	0.0	42.5	0.0	0.0	28.0	0.0	0.0	7.5			
21	0.0	0.0	93.4	0.0	0.0	48.3	0.0	0.0	33.8	0.0	0.0	13.3	0.0	0.0	5.8
25	0.0	0.0	102.5	0.0	0.0	57.4	0.0	0.0	42.9	0.0	0.0	22.4	0.0	0.0	14.9
27	0.0	0.0	105.9	0.0	0.0	60.9	0.0	0.0	46.3	0.0	0.0	25.9	0.0	0.0	18.4

Building: **Multi-Family High-rise** **City:** **Poughkeepsie** **HVAC:** **Steam Boiler Only** **Measure:** **Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF	kWh/ kSF	kW/ kSF	therm/ kSF
11	0.0	0.0	437.9												
19	0.0	0.0	508.5	0.0	0.0	70.6									
30	0.0	0.0	551.7	0.0	0.0	113.8	0.0	0.0	43.2						
38	0.0	0.0	570.5	0.0	0.0	132.6	0.0	0.0	62.0	0.0	0.0	18.9			
49	0.0	0.0	585.5	0.0	0.0	147.6	0.0	0.0	77.0	0.0	0.0	33.8	0.0	0.0	14.9
60	0.0	0.0	594.8	0.0	0.0	157.0	0.0	0.0	86.3	0.0	0.0	43.2	0.0	0.0	24.3

Single-family Residential Infiltration Reduction

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
City	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm
Albany	1.8	0.006	2.2	34.0	0.002	50.8	0.006	1.1	0.000	2.2	50.1	0.000
Buffalo	1.6	0.004	2.4	38.8	0.005	55.6	0.004	1.3	0.000	2.4	55.2	0.000
Messina	1.5	0.001	2.7	46.4	0.001	63.0	0.001	1.4	0.000	2.7	62.8	0.000
NYC	2.3	0.004	1.7	21.0	0.003	39.8	0.004	0.8	0.000	1.7	38.4	0.000
Syracuse	1.8	0.003	2.4	37.3	0.003	55.1	0.003	1.2	0.000	2.4	54.6	0.000
Binghamton	1.3	0.004	2.2	35.0	0.002	49.8	0.004	1.1	0.000	2.2	49.5	0.000
Poughkeepsie	1.9	0.004	1.9	24.8	0.003	43.5	0.004	1.0	0.000	1.9	42.7	0.000

Multi-Family Low-rise Infiltration Reduction

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
City	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	Therm/cfm	kWh/cfm	kW/cfm
Albany	1.5	0.004	2.4	33.5	0.004	40.0	0.004	1.4	0.000	2.4	39.9	0.000
Buffalo	1.0	0.003	2.3	31.2	0.002	36.6	0.003	1.1	0.000	2.3	36.7	0.000
Messina	1.3	0.001	2.7	44.5	0.001	44.6	0.001	1.2	0.000	2.7	44.5	0.000
NYC	1.5	0.003	1.9	21.2	0.003	29.6	0.003	1.1	0.000	1.9	29.2	0.000
Syracuse	1.6	0.004	2.5	34.1	0.004	42.2	0.004	1.6	0.000	2.5	42.2	0.000
Binghamton	1.5	0.003	2.5	32.7	0.003	40.2	0.003	1.6	0.000	2.5	40.3	0.000
Poughkeepsie	1.5	0.002	2.2	24.7	0.003	29.8	0.002	1.1	0.000	2.2	29.5	0.000

Multi-Family High-rise Infiltration Reduction

Impact per unit of infiltration reduction (cfm)

City	kWh/cfm	kW/cfm	Therm/cfm
Albany	-1.1	0.002	7.0
Buffalo	-1.1	0.002	6.5
Messina	-0.6	0.002	8.6
NYC	0.0	0.003	5.5
Syracuse	-1.2	0.006	7.2
Binghamton	-1.2	0.000	7.1
Poughkeepsie	-1.2	0.005	5.6

Impact per kSF square foot

City	Vintage	kWh/ 1000 SF	kW/ 1,000SF	Therm/ 1,000SF
Albany	Old	73	0.128	30
Albany	Average	22	0.099	16
Binghamton	Old	64	0.116	33
Binghamton	Average	11	0.085	17
Buffalo	Old	68	0.101	34
Buffalo	Average	20	0.079	19
Massena	Old	66	0.127	30
Massena	Average	20	0.098	17
NYC	Old	118	0.119	29
NYC	Average	56	0.098	17
Syracuse	Old	73	0.195	29
Syracuse	Average	23	0.092	16

Baseline infiltration rate for old building is 1.0 ACH.
Baseline infiltration rate for average building is 0.5 ACH.
Energy savings based on a 15% reduction.

Commercial Roof Insulation Upgrade

Roof Insulation - Assembly

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	994	0.000	0.0
	AC with gas heat	34	0.018	43.2
	Air source heat pump	768	0.000	0.1
	Electric heat only	979	0.032	0.1
	Gas heat only	11	0.000	43.3
Binghamton	AC with electric heat	964	0.009	0.1
	AC with gas heat	30	0.038	43.3

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Air source heat pump	843	0.009	0.0
	Electric heat only	961	0.091	0.1
	Gas heat only	13	0.000	44.2
Buffalo	AC with electric heat	920	0.032	0.0
	AC with gas heat	25	0.035	41.5
	Air source heat pump	674	0.032	0.1
	Electric heat only	916	0.221	0.1
	Gas heat only	11	0.000	42.0
Massena	AC with electric heat	1,823	0.050	0.0
	AC with gas heat	54	0.053	82.1
	Air source heat pump	1,442	0.050	0.1
	Electric heat only	1,842	0.103	0.1
	Gas heat only	35	0.000	84.3
NYC	AC with electric heat	425	0.000	0.0
	AC with gas heat	37	0.026	18.4
	Air source heat pump	248	0.000	0.0
	Electric heat only	405	0.021	0.1
	Gas heat only	0	0.000	20.4
Poughkeepsie	AC with electric heat	1,005	0.047	0.1
	AC with gas heat	36	0.050	44.3
	Air source heat pump	778	0.047	0.0
	Electric heat only	991	0.012	0.1
	Gas heat only	15	0.000	44.7
Syracuse	AC with electric heat	789	0.021	0.0
	AC with gas heat	30	0.044	35.1
	Air source heat pump	789	0.021	0.1
	Electric heat only	778	0.024	0.1
	Gas heat only	6	0.000	36.1

Roof Insulation - Auto Repair

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with electric heat	564	0.000	0.2
	AC with gas heat	32	0.000	25.2
	Air source heat pump	407	0.000	0.0
	Electric heat only	524	0.019	0.0
Albany	Gas heat only	16	0.000	24.1
	AC with electric heat	489	0.039	0.2
	AC with gas heat	24	0.000	21.7
	Air source heat pump	316	0.000	0.0
	Electric heat only	441	0.039	0.2
Binghamton	Gas heat only	12	0.000	20.0
Buffalo	AC with electric heat	500	0.000	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with gas heat	23	0.000	20.8
	Air source heat pump	315	0.000	0.0
	Electric heat only	490	0.019	0.0
	Gas heat only	13	0.000	20.6
Massena	AC with electric heat	585	0.000	0.0
	AC with gas heat	32	0.000	25.8
	Air source heat pump	377	0.000	0.2
	Electric heat only	564	0.000	0.0
	Gas heat only	18	0.000	25.6
N YC	AC with electric heat	915	0.000	0.0
	AC with gas heat	56	0.000	41.2
	Air source heat pump	431	0.000	0.0
	Electric heat only	882	0.000	0.0
	Gas heat only	33	0.000	40.6
Poughkeepsie	AC with electric heat	754	0.019	0.2
	AC with gas heat	41	0.019	33.4
	Air source heat pump	532	0.019	0.0
	Electric heat only	748	0.019	0.2
	Gas heat only	23	0.000	33.8
Syracuse	AC with electric heat	584	0.000	0.0
	AC with gas heat	34	0.000	26.4
	Air source heat pump	423	0.000	0.0
	Electric heat only	593	0.019	0.0
	Gas heat only	18	0.000	27.6

Roof Insulation - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	847	0.045	0.0
	AC with gas heat	-19	0.047	42.5
	Air source heat pump	682	0.045	0.0
	Electric heat only	895	0.011	0.0
	Gas heat only	2	0.000	43.5
Binghamton	AC with electric heat	740	0.023	0.0
	AC with gas heat	-33	0.023	38.2
	Air source heat pump	604	0.022	0.0
	Electric heat only	800	0.022	0.0
	Gas heat only	-3	0.000	40.1
Buffalo	AC with electric heat	707	0.025	0.0
	AC with gas heat	-31	0.025	36.3
	Air source heat pump	509	0.025	0.0
	Electric heat only	774	0.009	0.0
	Gas heat only	-5	0.000	38.2

	AC with electric heat	1213	0.043	0.0
	AC with gas heat	2	0.044	59.2
	Air source heat pump	1072	0.043	0.0
	Electric heat only	1263	-0.022	0.0
Massena	Gas heat only	18	0.000	60.7
	AC with electric heat	290	0.027	0.0
	AC with gas heat	-41	0.030	17.1
	Air source heat pump	141	0.027	0.0
	Electric heat only	341	0.008	0.0
NYC	Gas heat only	-32	0.000	19.0
	AC with electric heat	615	0.030	0.0
	AC with gas heat	-33	0.030	32.2
	Air source heat pump	536	0.030	0.0
	Electric heat only	680	0.014	0.0
Poughkeepsie	Gas heat only	-7	0.000	33.9
	AC with electric heat	751	0.034	0.0
	AC with gas heat	-19	0.034	38.1
	Air source heat pump	534	0.034	0.0
	Electric heat only	810	0.014	0.0
Syracuse	Gas heat only	-2	0.000	40.3

Roof Insulation - Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1009	0.000	0.5
	AC with gas heat	38	0.000	45.5
	Electric heat only	993	0.000	0.5
	Gas heat only	22	0.000	46.0
Binghamton	AC with electric heat	999	0.000	0.5
	AC with gas heat	30	0.000	45.5
	Electric heat only	1023	0.000	0.5
	Gas heat only	24	0.000	47.0
Buffalo	AC with electric heat	1066	0.000	0.5
	AC with gas heat	36	0.000	48.0
	Electric heat only	1036	0.000	0.5
	Gas heat only	22	0.000	47.0
Massena	AC with electric heat	1055	0.000	0.5
	AC with gas heat	33	0.000	47.0
	Electric heat only	1074	0.000	0.5
	Gas heat only	26	0.000	49.5
NYC	AC with electric heat	755	0.000	0.5
	AC with gas heat	61	0.000	34.0
	Electric heat only	988	0.000	0.5
	Gas heat only	24	0.000	46.5
Poughkeepsie	AC with electric heat	994	0.050	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with gas heat	47	0.000	45.5
	Electric heat only	994	0.000	0.5
	Gas heat only	24	0.000	46.0
Syracuse	AC with electric heat	1023	0.000	0.5
	AC with gas heat	43	0.050	46.5
	Electric heat only	1097	0.000	0.5
	Gas heat only	27	0.000	50.5

Roof Insulation - Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	946	0.025	0.3
	AC with gas heat	51	0.050	42.8
	Electric heat only	941	0.000	0.3
	Gas heat only	36	0.000	43.3
Binghamton	AC with electric heat	789	0.025	0.0
	AC with gas heat	42	0.025	35.0
	Electric heat only	790	0.100	0.3
	Gas heat only	32	0.000	35.5
Buffalo	AC with electric heat	832	0.025	0.3
	AC with gas heat	43	0.025	37.8
	Electric heat only	797	0.000	0.3
	Gas heat only	31	0.000	36.8
Massena	AC with electric heat	944	0.050	0.3
	AC with gas heat	54	0.050	42.5
	Electric heat only	926	0.225	0.0
	Gas heat only	37	0.000	42.5
NYC	AC with electric heat	698	0.000	0.0
	AC with gas heat	53	0.000	32.0
	Electric heat only	688	0.000	0.0
	Gas heat only	29	0.000	32.3
Poughkeepsie	AC with electric heat	852	0.050	0.3
	AC with gas heat	57	0.025	39.5
	Electric heat only	841	0.000	0.3
	Gas heat only	40	0.000	39.8
Syracuse	AC with electric heat	915	0.025	0.3
	AC with gas heat	55	0.025	41.5
	Electric heat only	930	0.025	0.0
	Gas heat only	39	0.000	43.0

Roof Insulation – Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with electric heat	847	0.045	0.0
	AC with gas heat	-19	0.047	42.5
	Air source heat pump	682	0.045	0.0
	Electric heat only	895	0.011	0.0
Albany	Gas heat only	2	0.000	43.5
	AC with electric heat	740	0.023	0.0
	AC with gas heat	-33	0.023	38.2
	Air source heat pump	604	0.022	0.0
	Electric heat only	800	0.022	0.0
Binghamton	Gas heat only	-3	0.000	40.1
	AC with electric heat	707	0.025	0.0
	AC with gas heat	-31	0.025	36.3
	Air source heat pump	509	0.025	0.0
	Electric heat only	774	0.009	0.0
Buffalo	Gas heat only	-5	0.000	38.2
	AC with electric heat	1213	0.043	0.0
	AC with gas heat	2	0.044	59.2
	Air source heat pump	1072	0.043	0.0
	Electric heat only	1263	-0.022	0.0
Massena	Gas heat only	18	0.000	60.7
	AC with electric heat	290	0.027	0.0
	AC with gas heat	-41	0.030	17.1
	Air source heat pump	141	0.027	0.0
	Electric heat only	341	0.008	0.0
NYC	Gas heat only	-32	0.000	19.0
	AC with electric heat	615	0.030	0.0
	AC with gas heat	-33	0.030	32.2
	Air source heat pump	536	0.030	0.0
	Electric heat only	680	0.014	0.0
Poughkeepsie	Gas heat only	-7	0.000	33.9
	AC with electric heat	751	0.034	0.0
	AC with gas heat	-19	0.034	38.1
	Air source heat pump	534	0.034	0.0
	Electric heat only	810	0.014	0.0
Syracuse	Gas heat only	-2	0.000	40.3

Roof Insulation – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with electric heat	929.2	0.023	0.0
	AC with gas heat	44.6	0.024	44.1
	Air source heat pump	585.4	0.023	0.0
Albany	Electric heat only	937.3	0.000	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Gas heat only	51.2	0.000	44.1
	AC with electric heat	968.31	0.015	0
	AC with gas heat	46.13	0.016	45.89
	Air source heat pump	601.99	0.016	0.01
	Electric heat only	976.42	0	0.01
Binghamton	Gas heat only	54.68	0	45.86
Buffalo	AC with electric heat	929.55	0.017	0
	AC with gas heat	43.78	0.017	44.23
	Air source heat pump	570.1	0.018	0.01
	Electric heat only	939.85	0	0.02
Buffalo	Gas heat only	54.07	0	44.2
	AC with electric heat	1079.08	0.025	0.01
	AC with gas heat	48	0.026	50.82
	Air source heat pump	724.88	0.025	0
	Electric heat only	1087.71	0	0.01
Massena	Gas heat only	54.87	0	50.86
	AC with electric heat	654.92	0.011	0.01
	AC with gas heat	54.62	0.012	30.9
	Air source heat pump	344.94	0.01	0.01
	Electric heat only	647.28	0	0.01
NYC	Gas heat only	49.87	0	30.63
	AC with electric heat	828.65	0.016	0
	AC with gas heat	48.18	0.016	39.47
	Air source heat pump	504.04	0.016	0.01
	Electric heat only	833.7	0	0.02
Poughkeepsie	Gas heat only	53.81	0	39.46
	AC with electric heat	922.95	0.018	0
	AC with gas heat	49.54	0.018	43.6
	Air source heat pump	579.35	0.018	0
	Electric heat only	926.66	0	0.01
Syracuse	Gas heat only	54.2	0	43.54

Roof Insulation – Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with gas heat	-4.3	0.073	12.9
	AC with electric heat	264.3	0.073	0.0
	Air source heat pump	235.0	0.073	0.0
	Electric heat only	272.9	0.000	0.0
Albany	Gas heat only	0.3	0.000	13.1
	AC with gas heat	-10.7	-0.007	13.2
	AC with electric heat	264.8	-0.007	0.0
Buffalo	Air source heat pump	235.2	-0.007	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Electric heat only	277.7	0.000	0.0
	Gas heat only	0.5	0.000	13.2
Massena	AC with gas heat	-5.9	0.067	15.3
	AC with electric heat	314.8	0.067	0.0
	Air source heat pump	292.9	0.067	0.0
	Electric heat only	322.8	0.000	0.0
	Gas heat only	0.5	0.000	15.3
NYC	AC with gas heat	-1.8	0.027	8.6
	AC with electric heat	175.6	0.027	0.0
	Air source heat pump	139.9	0.027	0.0
	Electric heat only	182.6	0.000	0.0
	Gas heat only	0.1	0.000	8.8
Syracuse	AC with gas heat	-0.4	0.060	12.7
	AC with electric heat	267.5	0.060	0.0
	Air source heat pump	242.0	0.060	0.0
	Electric heat only	270.5	0.000	0.0
	Gas heat only	0.3	0.000	12.9
Binghamton	AC with gas heat	-8.9	-0.013	13.6
	AC with electric heat	276.1	-0.013	0.0
	Air source heat pump	245.4	-0.013	0.0
	Electric heat only	289.3	0.033	0.0
	Gas heat only	1.1	0.000	13.9
Poughkeepsie	AC with gas heat	-4.8	-0.033	10.9
	AC with electric heat	220.8	-0.033	0.0
	Air source heat pump	188.2	-0.033	0.0
	Electric heat only	230.2	0.000	0.0
	Gas heat only	0.5	0.000	11.1

Roof Insulation - Elementary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1456	0.130	0.1
	AC with gas heat	121	0.134	59.9
	Air source heat pump	916	0.130	0.1
	Electric heat only	1411	0.006	0.1
	Gas heat only	86	0.000	59.8
Binghamton	AC with electric heat	1369	0.030	0.0
	AC with gas heat	110	0.030	56.6
	Air source heat pump	813	0.030	0.0
	Electric heat only	1337	0.006	0.1
	Gas heat only	85	0.000	56.4
Buffalo	AC with electric heat	1366	0.360	0.0
	AC with gas heat	107	0.360	56.7

	Air source heat pump	831	0.360	0.0
	Electric heat only	1345	0.012	0.1
	Gas heat only	85	0.044	56.8
Massena	AC with electric heat	1560	0.134	0.0
	AC with gas heat	121	0.052	64.1
	Air source heat pump	1030	0.134	0.0
	Electric heat only	1519	-0.002	0.1
	Gas heat only	83	0.000	64.0
NYC	AC with electric heat	1072	0.206	0.0
	AC with gas heat	146	0.204	43.1
	Air source heat pump	550	0.208	0.0
	Electric heat only	1,000	0.046	0.1
	Gas heat only	86	0.098	42.5
Poughkeepsie	AC with electric heat	1371	0.352	0.0
	AC with gas heat	142	0.352	56.1
	Air source heat pump	842	0.350	0.0
	Electric heat only	1332	0.000	0.1
	Gas heat only	95	0.000	56.5
Syracuse	AC with electric heat	1326	0.056	0.1
	AC with gas heat	123	0.054	54.3
	Air source heat pump	799	0.056	0.1
	Electric heat only	1267	-0.014	0.1
	Gas heat only	79	0.000	53.6

Roof Insulation – Religious Worship

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	994	0.000	0.0
	AC with gas heat	34	0.018	43.2
	Air source heat pump	768	0.000	0.1
	Electric heat only	979	0.032	0.1
	Gas heat only	11	0.000	43.3
Binghamton	AC with electric heat	964	0.009	0.1
	AC with gas heat	30	0.038	43.3
	Air source heat pump	843	0.009	0.0
	Electric heat only	961	0.091	0.1
	Gas heat only	13	0.000	44.2
Buffalo	AC with electric heat	920	0.032	0.0
	AC with gas heat	25	0.035	41.5
	Air source heat pump	674	0.032	0.1
	Electric heat only	916	0.221	0.1
	Gas heat only	11	0.000	42.0
Massena	AC with electric heat	1,823	0.050	0.0
	AC with gas heat	54	0.053	82.1
	Air source heat pump	1,442	0.050	0.1

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Electric heat only	1,842	0.103	0.1
	Gas heat only	35	0.000	84.3
NYC	AC with electric heat	425	0.000	0.0
	AC with gas heat	37	0.026	18.4
	Air source heat pump	248	0.000	0.0
	Electric heat only	405	0.021	0.1
	Gas heat only	-5	0.000	20.4
Poughkeepsie	AC with electric heat	1,005	0.047	0.1
	AC with gas heat	36	0.050	44.3
	Air source heat pump	778	0.047	0.0
	Electric heat only	991	0.012	0.1
	Gas heat only	15	0.000	44.7
Syracuse	AC with electric heat	789	0.021	0.0
	AC with gas heat	30	0.044	35.1
	Air source heat pump	789	0.021	0.1
	Electric heat only	778	0.024	0.1
	Gas heat only	6	0.000	36.1

Roof Insulation – Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	649	0.04	0
	AC with gas heat	28.2	0.04	31
	Air source heat pump	412	0.04	0
	Electric heat only	631.4	0	0
	Gas heat only	13.6	0	30.4
Binghamton	AC with electric heat	670.2	0.02	0
	AC with gas heat	24.8	0.02	32
	Air source heat pump	415.6	0.02	0
	Electric heat only	651.8	0	0.2
	Gas heat only	17.2	0	31.2
Buffalo	AC with electric heat	652.4	0	0
	AC with gas heat	24.8	0.02	31.2
	Air source heat pump	402.2	0.02	0
	Electric heat only	644.4	0	0
	Gas heat only	17.4	0	31
Massena	AC with electric heat	787.8	0.04	0
	AC with gas heat	33.6	0.02	36.8
	Air source heat pump	551.4	0.02	0
	Electric heat only	776.8	0	0
	Gas heat only	18.4	0	37.2
NYC	AC with electric heat	429.6	0.04	0
	AC with gas heat	36.8	0.04	20

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Air source heat pump	226.6	0.04	0
	Electric heat only	384.2	0	0
	Gas heat only	-1.6	0	19.6
Poughkeepsie	AC with electric heat	554.8	0.02	0
	AC with gas heat	31	0.02	26.4
	Air source heat pump	346.6	0.02	0
	Electric heat only	539.4	0	0
	Gas heat only	14.4	0	26.2
Syracuse	AC with electric heat	640.4	0.02	0
	AC with gas heat	33.2	0.04	30.2
	Air source heat pump	401.4	0.04	0
	Electric heat only	622.8	0	0
	Gas heat only	16.2	0	30

Roof Insulation – Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1013	0.063	0.2
	AC with gas heat	60	0.063	47.2
	Air source heat pump	671	0.063	0.2
	Electric heat only	977	0.000	0.2
	Gas heat only	38	0.000	46.4
Binghamton	AC with electric heat	1005	0.031	0.2
	AC with gas heat	50	0.031	47.3
	Air source heat pump	659	0.047	0.2
	Electric heat only	987	0.016	0.2
	Gas heat only	40	0.000	46.9
Buffalo	AC with electric heat	998	0.031	0.2
	AC with gas heat	53	0.031	46.9
	Air source heat pump	602	0.047	0.2
	Electric heat only	982	0.000	0.2
	Gas heat only	42	0.000	46.9
Massena	AC with electric heat	1174	0.063	0.2
	AC with gas heat	63	0.063	54.5
	Air source heat pump	792	0.047	0.0
	Electric heat only	1152	0.000	0.2
	Gas heat only	45	0.000	54.1
NYC	AC with electric heat	678	0.016	0.2
	AC with gas heat	66	0.031	31.6
	Air source heat pump	362	0.031	0.2
	Electric heat only	625	0.000	0.2
	Gas heat only	24	0.000	30.6
Poughkeepsie	AC with electric heat	836	0.063	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with gas heat	54	0.047	39.4
	Air source heat pump	511	0.047	0.0
	Electric heat only	800	0.000	0.2
	Gas heat only	32	0.000	38.4
Syracuse	AC with electric heat	1026	0.047	0.0
	AC with gas heat	65	0.047	48.0
	Air source heat pump	660	0.047	0.0
	Electric heat only	1006	0.000	0.2
	Gas heat only	46	0.000	47.8

Roof Insulation – Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1631	0.001	0.0
	AC with gas heat	13	0.001	65.6
	Air source heat pump	1215	0.001	0.0
	Electric heat only	1614	0.000	0.0
	Gas heat only	0	0.000	65.3
Binghamton	AC with electric heat	1656	0.037	0.0
	AC with gas heat	5	0.058	66.7
	Air source heat pump	1228	0.037	0.0
	Electric heat only	1650	0.000	0.0
	Gas heat only	0	0.000	66.7
Buffalo	AC with electric heat	1584	0.069	0.0
	AC with gas heat	0	0.084	64.2
	Air source heat pump	1141	0.069	0.0
	Electric heat only	1585	0.000	0.0
	Gas heat only	0	0.000	64.2
Massena	AC with electric heat	1522	0.001	0.0
	AC with gas heat	22	0.000	60.4
	Air source heat pump	1083	0.002	0.0
	Electric heat only	1501	0.000	0.0
	Gas heat only	0	0.000	60.5
NYC	AC with electric heat	1468	0.076	0.0
	AC with gas heat	48	0.121	60.3
	Air source heat pump	925	0.076	0.0
	Electric heat only	1416	0.000	0.0
	Gas heat only	0	0.000	60.1
Poughkeepsie	AC with electric heat	1612	0.129	0.0
	AC with gas heat	26	0.132	65.8
	Air source heat pump	1004	0.129	0.0
	Electric heat only	1586	0.000	0.0
	Gas heat only	0	0.000	65.8

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Syracuse	AC with electric heat	1817	0.039	0.0
	AC with gas heat	21	0.074	72.4
	Air source heat pump	1409	0.040	0.0
	Electric heat only	1796	0.000	0.0
	Gas heat only	0	0.000	72.5

Roof Insulation – Community College

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV reheat no econ with Air Cooled Chiller	-33	-0.001	4.5
	CV reheat no econ with Water Cooled Chiller	-30	0.000	4.5
	CV reheat econ with Air Cooled Chiller	0	-0.001	4.0
	CV reheat econ with Water Cooled Chiller	-5	0.000	4.0
	VAV reheat econ with Air Cooled Chiller	-6	0.042	2.1
	VAV reheat econ with Water Cooled Chiller	-8	0.043	2.1
Buffalo	CV reheat no econ with Air Cooled Chiller	-32	0.001	4.1
	CV reheat no econ with Water Cooled Chiller	-33	0.011	4.1
	CV reheat econ with Air Cooled Chiller	-1	0.001	3.7
	CV reheat econ with Water Cooled Chiller	-5	0.011	3.7
	VAV reheat econ with Air Cooled Chiller	9	0.034	4.5
	VAV reheat econ with Water Cooled Chiller	8	0.026	4.5
Massena	CV reheat no econ with Air Cooled Chiller	-36	0.001	4.6
	CV reheat no econ with Water Cooled Chiller	-34	0.001	4.6
	CV reheat econ with Air Cooled Chiller	-1	0.001	4.0
	CV reheat econ with Water Cooled Chiller	-6	0.001	4.0
	VAV reheat econ with Air Cooled Chiller	-1	0.067	2.4

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	VAV reheat econ with Water Cooled Chiller	-2	0.046	2.4
NYC	CV reheat no econ with Air Cooled Chiller	-39	0.001	5.8
	CV reheat no econ with Water Cooled Chiller	-30	0.000	5.9
	CV reheat econ with Air Cooled Chiller	12	0.001	4.1
	CV reheat econ with Water Cooled Chiller	2	0.000	4.1
	VAV reheat econ with Air Cooled Chiller	24	0.049	4.7
	VAV reheat econ with Water Cooled Chiller	20	0.032	4.7
Syracuse	CV reheat no econ with Air Cooled Chiller	-33	0.000	4.8
	CV reheat no econ with Water Cooled Chiller	-32	0.001	4.8
	CV reheat econ with Air Cooled Chiller	2	0.000	3.9
	CV reheat econ with Water Cooled Chiller	-3	0.001	3.9
	VAV reheat econ with Air Cooled Chiller	7	0.043	3.6
	VAV reheat econ with Water Cooled Chiller	5	0.030	3.6
Binghamton	CV reheat no econ with Air Cooled Chiller	-32	0.001	3.3
	CV reheat no econ with Water Cooled Chiller	-30	0.001	3.3
	CV reheat econ with Air Cooled Chiller	-2	0.001	3.3
	CV reheat econ with Water Cooled Chiller	-6	0.001	3.2
	VAV reheat econ with Air Cooled Chiller	-3	0.031	2.4
	VAV reheat econ with Water Cooled Chiller	-5	0.026	2.4
Poughkeepsie	CV reheat no econ with Air Cooled Chiller	-42	0.000	6.4
	CV reheat no econ with Water Cooled Chiller	-27	0.001	6.5
	CV reheat econ with Air Cooled Chiller	5	0.000	4.8

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	CV reheat econ with Water Cooled Chiller	1	0.001	4.8
	VAV reheat econ with Air Cooled Chiller	22	0.008	9.5
	VAV reheat econ with Water Cooled Chiller	17	0.018	9.5

Roof Insulation – University

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-18	0.003	5.6
	CV Econ Air Cooled	-3	0.003	3.3
	CV Econ Water Cooled	-1	0.003	3.3
	VAV Econ Air Cooled	5	0.003	3.0
	VAV Econ Water Cooled	8	0.003	2.8
Buffalo	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-18	0.002	5.9
	CV Econ Air Cooled	-2	0.002	3.6
	CV Econ Water Cooled	-1	0.001	3.1
	VAV Econ Air Cooled	-19	0.002	-2.1
	VAV Econ Water Cooled	-20	0.002	-1.9
Massena	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-24	0.001	5.2
	CV Econ Air Cooled	-1	0.002	3.2
	CV Econ Water Cooled	0	0.001	3.2
	VAV Econ Air Cooled	33	0.002	7.7
	VAV Econ Water Cooled	33	0.001	7.7
NYC	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-15	0.002	4.6
	CV Econ Air Cooled	-1	0.003	2.8
	CV Econ Water Cooled	0	0.002	2.8
	VAV Econ Air Cooled	11	0.003	4.0
	VAV Econ Water Cooled	10	0.002	3.9
Syracuse	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-20	0.002	5.0
	CV Econ Air Cooled	-3	0.002	3.0
	CV Econ Water Cooled	-1	0.002	3.0
	VAV Econ Air Cooled	13	0.002	3.0
	VAV Econ Water Cooled	20	0.057	4.5
Binghamton	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-24	0.002	5.9
	CV Econ Air Cooled	-3	0.001	3.6

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	CV Econ Water Cooled	-1	0.002	3.7
	VAV Econ Air Cooled	0	0.002	1.9
	VAV Econ Water Cooled	6	0.003	2.7
Poughkeepsie	CV No Econ Air Cooled			
	CV No Econ Water Cooled	-16	0.002	5.0
	CV Econ Air Cooled	-2	0.001	2.9
	CV Econ Water Cooled	-1	0.002	2.8
	VAV Econ Air Cooled	3	0.001	3.2
	VAV Econ Water Cooled	4	0.001	3.3

Roof Insulation – High School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-15	0.000	7.7
	CV No Econ Water Cooled	-12	0.000	7.8
	CV Econ Air Cooled	-11	0.000	7.5
	CV Econ Water Cooled	-8	0.000	7.5
	VAV Econ Air Cooled	-11	0.000	7.5
	VAV Econ Water Cooled	-8	0.000	7.5
Buffalo	CV No Econ Air Cooled	-17	0.000	6.1
	CV No Econ Water Cooled	-12	0.000	6.1
	CV Econ Air Cooled	-16	0.000	5.1
	CV Econ Water Cooled	-9	0.000	6.1
	VAV Econ Air Cooled	-16	0.000	5.1
	VAV Econ Water Cooled	-9	0.000	6.1
Massena	CV No Econ Air Cooled	-16	0.000	7.8
	CV No Econ Water Cooled	-13	0.000	7.8
	CV Econ Air Cooled	-12	0.000	7.7
	CV Econ Water Cooled	-9	0.000	7.7
	VAV Econ Air Cooled	-12	0.000	7.7
	VAV Econ Water Cooled	-9	0.000	7.7
NYC	CV No Econ Air Cooled	-14	0.000	4.1
	CV No Econ Water Cooled	-10	0.000	4.1
	CV Econ Air Cooled	-10	0.000	4.2
	CV Econ Water Cooled	-6	0.000	4.2
	VAV Econ Air Cooled	-10	0.000	4.2
	VAV Econ Water Cooled	-6	0.000	4.2
Syracuse	CV No Econ Air Cooled	-11	0.000	8.1
	CV No Econ Water Cooled	-10	0.000	6.7
	CV Econ Air Cooled	-10	0.000	6.7
	CV Econ Water Cooled	-7	0.000	6.7
	VAV Econ Air Cooled	-10	0.000	6.7
	VAV Econ Water Cooled	-7	0.000	6.7

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Binghamton	CV No Econ Air Cooled	-16	0.000	7.2
	CV No Econ Water Cooled	-12	0.000	7.2
	CV Econ Air Cooled	-12	0.000	7.0
	CV Econ Water Cooled	-8	0.000	7.0
	VAV Econ Air Cooled	-12	0.000	7.0
	VAV Econ Water Cooled	-8	0.000	7.0
Poughkeepsie	CV No Econ Air Cooled	-18	0.000	4.3
	CV No Econ Water Cooled	-13	0.000	4.3
	CV Econ Air Cooled	-11	0.000	5.3
	CV Econ Water Cooled	-8	0.000	5.3
	VAV Econ Air Cooled	-11	0.000	5.3
	VAV Econ Water Cooled	-8	0.000	5.3

Roof Insulation – Large Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-4	0.013	12.0
	CV No Econ Water Cooled	-2	0.008	12.0
	CV Econ Air Cooled	0	0.013	12.1
	CV Econ Water Cooled	1	0.008	12.1
	VAV Econ Air Cooled	-8	0.010	7.9
	VAV Econ Water Cooled	-9	0.007	7.9
Buffalo	CV No Econ Air Cooled	-5	0.003	11.7
	CV No Econ Water Cooled	-4	0.000	11.7
	CV Econ Air Cooled	-1	0.000	11.8
	CV Econ Water Cooled	-1	0.003	11.8
	VAV Econ Air Cooled	-11	0.003	8.6
	VAV Econ Water Cooled	-11	0.000	8.6
Massena	CV No Econ Air Cooled	-3	0.010	13.6
	CV No Econ Water Cooled	-5	0.003	13.6
	CV Econ Air Cooled	0	0.010	13.4
	CV Econ Water Cooled	-1	0.002	13.4
	VAV Econ Air Cooled	-4	0.013	9.9
	VAV Econ Water Cooled	-5	0.003	9.9
NYC	CV No Econ Air Cooled	-5	0.000	7.5
	CV No Econ Water Cooled	-3	0.000	7.5
	CV Econ Air Cooled	1	0.000	7.4
	CV Econ Water Cooled	-1	0.000	7.4
	VAV Econ Air Cooled	-12	0.008	5.9
	VAV Econ Water Cooled	-11	0.005	5.9
Syracuse	CV No Econ Air Cooled	-4	0.007	11.6
	CV No Econ Water Cooled	-3	0.005	11.6
	CV Econ Air Cooled	1	0.007	11.6

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	CV Econ Water Cooled	0	0.005	11.6
	VAV Econ Air Cooled	-9	0.010	8.1
	VAV Econ Water Cooled	-7	0.003	8.1
Binghamton	CV No Econ Air Cooled	-8	0.005	11.7
	CV No Econ Water Cooled	-5	0.003	11.7
	CV Econ Air Cooled	-2	0.003	11.7
	CV Econ Water Cooled	-1	0.003	11.7
	VAV Econ Air Cooled	-11	0.005	8.1
	VAV Econ Water Cooled	-13	0.003	8.1
Poughkeepsie	CV No Econ Air Cooled	-3	0.005	10.2
	CV No Econ Water Cooled	-4	0.003	10.2
	CV Econ Air Cooled	0	0.005	10.3
	CV Econ Water Cooled	1	0.003	10.3
	VAV Econ Air Cooled	-13	0.005	5.7
	VAV Econ Water Cooled	-12	0.003	5.7

Roof Insulation – Hospital

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-51	0.034	9.2
	CV No Econ Water Cooled	-40	0.023	9.2
	CV Econ Air Cooled	11	0.034	7.4
	CV Econ Water Cooled	7	0.023	7.4
	VAV Econ Air Cooled	12	0.044	25.6
	VAV Econ Water Cooled	12	0.028	25.6
Buffalo	CV No Econ Air Cooled	-58	0.012	9.0
	CV No Econ Water Cooled	-45	0.007	9.0
	CV Econ Air Cooled	4	0.012	7.4
	CV Econ Water Cooled	5	0.007	7.4
	VAV Econ Air Cooled	0	0.017	19.2
	VAV Econ Water Cooled	2	0.011	19.2
Massena	CV No Econ Air Cooled	-59	0.035	11.5
	CV No Econ Water Cooled	-39	0.018	11.5
	CV Econ Air Cooled	10	0.035	9.4
	CV Econ Water Cooled	10	0.017	9.4
	VAV Econ Air Cooled	8	0.043	23.9
	VAV Econ Water Cooled	7	0.019	22.1
NYC	CV No Econ Air Cooled	-40	0.040	5.2
	CV No Econ Water Cooled	-25	0.018	5.2
	CV Econ Air Cooled	19	0.040	4.2
	CV Econ Water Cooled	17	0.018	4.2
	VAV Econ Air Cooled	4	0.047	12.5
	VAV Econ Water Cooled	3	0.019	12.5

Syracuse	CV No Econ Air Cooled	-60	0.030	8.7
	CV No Econ Water Cooled	-46	0.018	8.7
	CV Econ Air Cooled	13	0.029	6.8
	CV Econ Water Cooled	9	0.019	6.8
	VAV Econ Air Cooled	10	0.037	22.3
	VAV Econ Water Cooled	5	0.023	22.3
Binghamton	CV No Econ Air Cooled	-61	0.017	8.9
	CV No Econ Water Cooled	-56	0.010	8.9
	CV Econ Air Cooled	8	0.017	7.3
	CV Econ Water Cooled	7	0.008	7.4
	VAV Econ Air Cooled	-4	0.023	20.8
	VAV Econ Water Cooled	-4	0.010	20.8
Poughkeepsie	CV No Econ Air Cooled	-47	0.016	7.4
	CV No Econ Water Cooled	-35	0.004	7.4
	CV Econ Air Cooled	15	0.016	6.4
	CV Econ Water Cooled	11	0.004	6.4
	VAV Econ Air Cooled	1	-0.065	12.2
	VAV Econ Water Cooled	4	0.014	12.2

Roof Insulation – Hotel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Air Cooled	-220	0.042	4.0
	CV No Econ Water Cooled	-221	0.036	4.0
	CV Econ Air Cooled	-207	0.042	4.1
	CV Econ Water Cooled	-207	0.036	4.1
	VAV Econ Air Cooled	-215	0.036	4.5
	VAV Econ Water Cooled	-215	0.036	4.5
Buffalo	CV No Econ Air Cooled	-334	0.031	3.8
	CV No Econ Water Cooled	-335	0.036	3.8
	CV Econ Air Cooled	-350	0.031	4.0
	CV Econ Water Cooled	-350	0.036	4.0
	VAV Econ Air Cooled	-359	0.031	4.3
	VAV Econ Water Cooled	-358	0.036	4.3
Massena	CV No Econ Air Cooled	-127	0.057	5.1
	CV No Econ Water Cooled	-132	0.057	5.1
	CV Econ Air Cooled	-105	0.057	5.3
	CV Econ Water Cooled	-105	0.057	5.3
	VAV Econ Air Cooled	-111	0.057	6.1
	VAV Econ Water Cooled	-111	0.057	6.1
NYC	CV No Econ Air Cooled	-215	0.062	2.7
	CV No Econ Water Cooled	-215	0.062	2.7
	CV Econ Air Cooled	-201	0.062	2.8
	CV Econ Water Cooled	-202	0.062	2.8
	VAV Econ Air Cooled	-207	0.062	2.0

	VAV Econ Water Cooled	-207	0.062	2.0
Syracuse	CV No Econ Air Cooled	-147	0.047	4.0
	CV No Econ Water Cooled	-149	0.047	4.0
	CV Econ Air Cooled	-131	0.047	4.1
	CV Econ Water Cooled	-131	0.047	4.1
	VAV Econ Air Cooled	-138	0.047	4.4
	VAV Econ Water Cooled	-138	0.052	4.4
Binghamton	CV No Econ Air Cooled	-380	0.031	4.2
	CV No Econ Water Cooled	-382	0.031	4.3
	CV Econ Air Cooled	-362	0.031	4.3
	CV Econ Water Cooled	-362	0.031	4.3
	VAV Econ Air Cooled	-370	0.031	4.5
	VAV Econ Water Cooled	-370	0.031	4.5
Poughkeepsie	CV No Econ Air Cooled	-397	0.042	3.7
	CV No Econ Water Cooled	-400	0.042	3.7
	CV Econ Air Cooled	-379	0.042	3.8
	CV Econ Water Cooled	-379	0.042	3.8
	VAV Econ Air Cooled	-385	0.036	3.5
	VAV Econ Water Cooled	-385	0.036	3.5

Roof Insulation – Large Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	CV No Econ Water Cooled	155	0.034	45.7
	CV Econ Air Cooled	260	0.040	52.8
	CV Econ Water Cooled	256	0.000	52.5
	VAV Econ Air Cooled	140	0.057	45.1
	VAV Econ Water Cooled	148	0.017	45.1
Buffalo	CV No Econ Air Cooled	106	0.023	35.1
	CV No Econ Water Cooled	75	0.017	35.2
	CV Econ Air Cooled	146	0.000	34.0
	CV Econ Water Cooled	131	0.000	34.1
	VAV Econ Air Cooled	83	0.000	37.3
	VAV Econ Water Cooled	85	0.000	37.3
Massena	CV No Econ Air Cooled	148	0.040	42.3
	CV No Econ Water Cooled	113	0.029	42.4
	CV Econ Air Cooled	153	0.000	34.6
	CV Econ Water Cooled	143	0.000	34.5
	VAV Econ Air Cooled	206	0.000	54.4
	VAV Econ Water Cooled	205	0.000	54.4
NYC	CV No Econ Air Cooled	153	0.046	34.3
	CV No Econ Water Cooled	45	0.023	34.2
	CV Econ Air Cooled	194	0.046	45.2
	CV Econ Water Cooled	178	0.000	45.2
	VAV Econ Air Cooled	23	0.000	10.7

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	VAV Econ Water Cooled	39	0.006	10.7
Syracuse	CV No Econ Air Cooled	326	0.046	52.5
	CV No Econ Water Cooled	234	0.023	52.6
	CV Econ Air Cooled	311	0.040	59.5
	CV Econ Water Cooled	298	0.000	59.1
	VAV Econ Air Cooled	134	0.051	44.9
	VAV Econ Water Cooled	147	0.029	45.0
Binghamton	CV No Econ Air Cooled	198	0.023	42.6
	CV No Econ Water Cooled	194	0.011	42.6
	CV Econ Air Cooled	128	0.029	32.3
	CV Econ Water Cooled	127	0.000	32.4
	VAV Econ Air Cooled	90	0.000	37.4
	VAV Econ Water Cooled	95	0.006	37.4
Poughkeepsie	CV No Econ Air Cooled	31	0.051	25.0
	CV No Econ Water Cooled	121	0.006	24.9
	CV Econ Air Cooled	161	0.000	35.7
	CV Econ Water Cooled	153	0.000	35.6
	VAV Econ Air Cooled	125	0.006	32.6
	VAV Econ Water Cooled	124	0.006	32.6

Roof Insulation – Dormitory

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	Fan coil with Air Cooled Chiller	70.3	0.064	11.8
	Fan coil with Water Cooled Chiller	91.4	0.058	11.8
	Heat only	16.1	0.004	11.2
Buffalo	Fan coil with Air Cooled Chiller	62.2	0.044	12.5
	Fan coil with Water Cooled Chiller	79.1	0.052	12.5
	Heat only	15.4	0.004	12.2
Massena	Fan coil with Air Cooled Chiller	68.2	0.054	14.4
	Fan coil with Water Cooled Chiller	90.7	0.262	14.4
	Heat only	16.5	0.006	14.0
NYC	Fan coil with Air Cooled Chiller	13.0	0.036	10.4
	Fan coil with Water Cooled Chiller	15.3	-0.028	10.4
	Heat only	3.7	0.000	10.3
Syracuse	Fan coil with Air Cooled Chiller	72.8	0.060	12.1
	Fan coil with Water Cooled Chiller	94.9	0.066	12.1
	Heat only	16.5	0.004	11.5

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Binghamton	Fan coil with Air Cooled Chiller	56.3	0.042	12.4
	Fan coil with Water Cooled Chiller	71.8	0.054	12.4
	Heat only	15.2	0.004	11.9
Poughkeepsie	Fan coil with Air Cooled Chiller	69.7	0.044	10.5
	Fan coil with Water Cooled Chiller	93.7	0.062	10.5
	Heat only	17.1	0.004	10.1

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-24	7/31/2013
7-13-25	7/31/2013
7-13-26	7/31/2013

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APPENDIX F

WINDOW AND HIGH PERFORMANCE GLAZING

SINGLE-FAMILY RESIDENTIAL ENERGY STAR WINDOWS

Albany

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	96.4	0.127	17.0	386.8	0.124	481.6	0.127	7.7	0.000	16.9	393.0	0.000
2 pane	47.7	0.067	5.2	147.3	0.074	167.5	0.067	2.1	0.000	5.2	122.0	0.000
Code	1.3	0.003	3.7	49.3	0.003	81.1	0.003	1.8	0.000	3.7	81.5	0.000

Buffalo

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	86.5	0.107	20.4	440.2	0.104	553.0	0.107	9.8	0.000	20.4	476.3	0.000
2 pane	43.7	0.060	7.2	176.4	0.057	210.2	0.060	3.4	0.000	7.2	169.9	0.000
Code	1.7	0.003	3.8	54.0	0.003	85.0	0.003	1.9	0.000	3.8	85.1	0.000

Massena

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	84.4	0.111	21.0	490.9	0.117	566.9	0.111	9.6	0.000	20.9	492.0	0.000
2 pane	40.9	0.057	6.5	183.2	0.064	194.4	0.057	2.7	0.000	6.5	156.1	0.000
Code	2.0	0.000	4.4	68.2	0.000	98.5	0.000	2.2	0.000	4.4	98.6	0.000

NYC

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	125.5	0.117	9.2	252.7	0.124	336.0	0.117	4.0	0.000	9.1	214.6	0.000
2 pane	64.5	0.060	1.6	98.7	0.060	106.3	0.060	0.5	0.000	1.5	42.4	0.000
Code	1.1	0.003	2.7	27.4	0.003	59.9	0.003	1.3	0.000	2.7	60.2	0.000

Syracuse

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	94.5	0.091	18.4	396.4	0.101	510.4	0.091	8.7	0.000	18.3	424.6	0.000
2 pane	47.6	0.064	6.0	153.9	0.067	185.3	0.064	2.6	0.000	5.9	140.4	0.000
Code	1.1	0.003	3.7	48.6	0.000	81.0	0.003	1.8	0.000	3.7	81.8	0.000

Binghamton

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	75.7	0.104	19.3	420.4	0.107	517.5	0.104	9.3	0.000	19.2	451.1	0.000
2 pane	36.2	0.054	6.1	156.3	0.054	177.3	0.054	2.6	0.000	6.0	143.8	0.000
Code	1.6	0.003	3.9	56.8	0.003	88.2	0.003	2.1	0.000	3.9	88.6	0.000

Poughkeepsie

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	86.6	0.104	11.9	277.1	0.117	359.1	0.104	5.5	0.000	11.8	277.8	0.000
2 pane	44.0	0.054	3.2	109.2	0.060	121.1	0.054	1.3	0.000	3.1	78.4	0.000
Code	1.4	0.000	3.4	38.8	0.000	72.3	0.000	1.6	0.000	3.4	72.6	0.000

Multi-family Low-rise Energy Star Windows

Albany

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	148.4	0.228	87.9	1269.5	0.221	1668.6	0.228	69.3	0.057	87.9	1589.5	0.057
2 pane	72.1	0.117	36.3	531.0	0.114	716.9	0.117	31.5	0.057	36.3	676.2	0.057
Code	6.4	0.003	11.3	134.3	0.007	173.4	0.003	6.7	0.003	11.3	173.5	0.003

Buffalo

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	121.1	0.164	90.8	1315.5	0.158	1688.8	0.164	55.1	0.030	90.8	1622.9	0.030
2 pane	56.3	0.084	37.3	543.2	0.084	701.6	0.084	21.9	0.007	37.3	667.2	0.007
Code	5.6	0.003	12.0	134.9	0.003	173.7	0.003	6.2	0.000	12.0	174.4	0.000

Massena

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	132.4	0.171	100.4	1389.5	0.168	1939.0	0.171	63.2	0.027	100.4	1869.9	0.027
2 pane	62.6	0.091	41.5	538.2	0.091	833.7	0.091	26.0	0.017	41.5	797.0	0.017
Code	5.7	0.003	12.9	170.2	0.003	195.6	0.003	7.3	0.000	12.9	197.0	0.000

NYC

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	184.9	0.188	56.6	830.1	0.184	1163.5	0.188	61.7	0.000	56.6	1040.4	0.000
2 pane	94.1	0.097	21.7	347.3	0.094	482.7	0.097	28.2	0.000	21.7	416.8	0.000
Code	4.6	0.003	8.7	84.5	0.003	125.1	0.003	4.3	0.000	8.7	124.8	0.000

Syracuse

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	147.7	0.225	90.1	1330.8	0.218	1689.9	0.225	67.1	0.050	90.1	1609.5	0.050
2 pane	71.2	0.117	38.1	567.5	0.114	723.8	0.117	29.5	0.034	38.1	682.1	0.034
Code	6.6	0.007	11.7	134.6	0.007	174.6	0.007	7.2	0.000	11.7	175.2	0.000

Binghamton

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	122.3	0.174	99.3	1426.3	0.168	1832.4	0.174	61.0	0.007	99.3	1771.0	0.007
2 pane	57.3	0.091	42.1	605.1	0.087	793.6	0.091	26.0	0.003	42.1	762.2	0.003
Code	6.8	0.003	12.1	137.8	0.003	177.9	0.003	7.3	0.003	12.1	178.3	0.003

Poughkeepsie

	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
Baseline	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	147.8	0.158	74.3	1015.5	0.154	1345.2	0.158	65.1	0.030	74.3	1262.5	0.030
2 pane	74.1	0.077	30.3	434.3	0.077	589.0	0.077	29.4	0.013	30.3	544.4	0.013
Code	5.8	0.000	11.8	114.4	0.000	147.9	0.000	6.2	0.000	11.8	148.4	0.000

COMMERCIAL HIGH PERFORMANCE WINDOWS

High-Performance Windows – Assembly

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2222	0.156	0.0
	AC with gas heat	270	0.156	86.5
	Air source heat pump	1951	0.156	0.0
	Electric heat only	1992	0.000	0.0
	Gas heat only	0	0.000	86.5
Binghamton	AC with electric heat	2345	0.156	0.0
	AC with gas heat	220	0.156	96.6
	Air source heat pump	2278	0.156	0.0
	Electric heat only	2163	0.000	0.0
	Gas heat only	0	0.000	96.6
Buffalo	AC with electric heat	2169	0.156	0.0
	AC with gas heat	235	0.156	88.2
	Air source heat pump	1703	0.156	0.0
	Electric heat only	1985	0.000	0.0
	Gas heat only	0	0.000	88.2
Massena	AC with electric heat	4296	0.156	0.0
	AC with gas heat	304	0.156	182.9
	Air source heat pump	3878	0.156	0.0
	Electric heat only	4083	0.000	0.0
	Gas heat only	0	0.000	182.9
NYC	AC with electric heat	1048	0.156	0.0
	AC with gas heat	389	0.156	30.1
	Air source heat pump	825	0.156	0.0
	Electric heat only	714	0.000	0.0
	Gas heat only	0	0.000	30.1
Poughkeepsie	AC with electric heat	2053	0.156	0.0
	AC with gas heat	262	0.156	83.4
	Air source heat pump	1861	0.156	0.0
	Electric heat only	1843	0.000	0.0
	Gas heat only	0	0.000	83.4
Syracuse	AC with electric heat	1775	0.156	0.0
	AC with gas heat	267	0.156	68.7
	Air source heat pump	1852	0.156	0.0
	Electric heat only	1541	0.000	0.0
	Gas heat only	0	0.000	68.7

High-Performance Windows - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1714	0.156	0.0
	AC with gas heat	294	0.156	68.9
	Air source heat pump	1520	0.156	0.0
	Electric heat only	1563	0.000	0.0
	Gas heat only	0	0.000	68.9
Binghamton	AC with electric heat	1493	0.156	0.0
	AC with gas heat	223	0.156	60.4
	Air source heat pump	1596	0.156	0.0
	Electric heat only	1324	0.000	0.0
	Gas heat only	0	0.000	60.4
Buffalo	AC with electric heat	1794	0.156	0.0
	AC with gas heat	250	0.156	72.5

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Air source heat pump	1454	0.156	0.0
	Electric heat only	1594	0.000	0.0
	Gas heat only	0	0.000	72.5
Massena	AC with electric heat	1934	0.156	0.0
	AC with gas heat	284	0.156	78.0
	Air source heat pump	1750	0.156	0.0
	Electric heat only	1751	0.000	0.0
	Gas heat only	0	0.000	78.0
NYC	AC with electric heat	860	0.156	0.0
	AC with gas heat	353	0.156	25.0
	Air source heat pump	735	0.156	0.0
	Electric heat only	561	0.000	0.0
	Gas heat only	0	0.000	25.0
Poughkeepsie	AC with electric heat	1137	0.156	0.0
	AC with gas heat	273	0.156	41.0
	Air source heat pump	916	0.156	0.0
	Electric heat only	959	0.000	0.0
	Gas heat only	0	0.000	41.0
Syracuse	AC with electric heat	1433	0.156	0.0
	AC with gas heat	281	0.156	54.0
	Air source heat pump	1361	0.156	0.0
	Electric heat only	1292	0.000	0.0
	Gas heat only	0	0.000	54.0

High-Performance Windows -Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2032	0.156	0.0
	AC with gas heat	298	0.156	81.2
	Air source heat pump	1504	0.156	0.0
	Electric heat only	1810	0.000	0.0
	Gas heat only	0	0.000	81.2
Binghamton	AC with electric heat	2086	0.156	0.0
	AC with gas heat	257	0.156	86.0
	Air source heat pump	1544	0.156	0.0
	Electric heat only	1814	0.000	0.0
	Gas heat only	0	0.000	86.0
Buffalo	AC with electric heat	2302	0.156	0.0
	AC with gas heat	281	0.156	94.8
	Air source heat pump	1703	0.156	0.0
	Electric heat only	1789	0.000	0.0
	Gas heat only	0	0.000	94.8
Massena	AC with electric heat	2158	0.156	0.0
	AC with gas heat	284	0.156	87.1
	Air source heat pump	1597	0.156	0.0
	Electric heat only	1845	0.000	0.0
	Gas heat only	0	0.000	87.1
NYC	AC with electric heat	1694	0.156	0.2
	AC with gas heat	382	0.156	64.0
	Air source heat pump	1254	0.156	0.0
	Electric heat only	1905	0.000	0.0
	Gas heat only	0	0.000	64.0
Poughkeepsie	AC with electric heat	1801	0.156	0.0
	AC with gas heat	308	0.156	71.9
	Air source heat pump	1333	0.156	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Electric heat only	1927	0.000	0.0
	Gas heat only	0	0.000	71.9
Syracuse	AC with electric heat	2066	0.156	0.2
	AC with gas heat	303	0.156	83.1
	Air source heat pump	1529	0.156	0.0
	Electric heat only	1867	0.000	0.0
	Gas heat only	0	0.000	83.1

High-Performance Windows -Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2670	0.156	0.0
	AC with gas heat	380	0.156	108.6
	Air source heat pump	1976	0.156	0.0
	Electric heat only	2426	0.000	0.0
	Gas heat only	0	0.000	108.6
Binghamton	AC with electric heat	2778	0.156	0.0
	AC with gas heat	338	0.156	115.2
	Air source heat pump	2056	0.156	0.0
	Electric heat only	2614	0.000	0.0
	Gas heat only	0	0.000	115.2
Buffalo	AC with electric heat	2977	0.156	0.0
	AC with gas heat	352	0.156	124.3
	Air source heat pump	2203	0.156	0.0
	Electric heat only	2751	0.000	0.0
	Gas heat only	0	0.000	124.3
Massena	AC with electric heat	2812	0.156	0.0
	AC with gas heat	372	0.156	115.5
	Air source heat pump	2081	0.156	0.0
	Electric heat only	2618	0.000	0.0
	Gas heat only	0	0.000	115.5
NYC	AC with electric heat	2325	0.156	0.0
	AC with gas heat	449	0.156	91.7
	Air source heat pump	1721	0.156	0.0
	Electric heat only	2068	0.000	0.0
	Gas heat only	0	0.000	91.7
Poughkeepsie	AC with electric heat	2161	0.156	0.0
	AC with gas heat	373	0.156	87.6
	Air source heat pump	1599	0.156	0.0
	Electric heat only	1921	0.000	0.0
	Gas heat only	0	0.000	87.6
Syracuse	AC with electric heat	3060	0.156	0.0
	AC with gas heat	407	0.156	127.3
	Air source heat pump	2264	0.156	0.0
	Electric heat only	2874	0.000	0.0
	Gas heat only	0	0.000	127.3

High-Performance Windows – Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1714	0.156	0.0
	AC with gas heat	294	0.156	68.9
	Air source heat pump	1520	0.156	0.0
	Electric heat only	1563	0.000	0.0
	Gas heat only	0	0.000	68.9
Binghamton	AC with electric heat	1493	0.156	0.0
	AC with gas heat	223	0.156	60.4

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Air source heat pump	1596	0.156	0.0
	Electric heat only	1324	0.000	0.0
	Gas heat only	0	0.000	60.4
Buffalo	AC with electric heat	1794	0.156	0.0
	AC with gas heat	250	0.156	72.5
	Air source heat pump	1454	0.156	0.0
	Electric heat only	1594	0.000	0.0
	Gas heat only	0	0.000	72.5
Massena	AC with electric heat	1934	0.156	0.0
	AC with gas heat	284	0.156	78.0
	Air source heat pump	1750	0.156	0.0
	Electric heat only	1751	0.000	0.0
	Gas heat only	0	0.000	78.0
NYC	AC with electric heat	860	0.156	0.0
	AC with gas heat	353	0.156	25.0
	Air source heat pump	735	0.156	0.0
	Electric heat only	561	0.000	0.0
	Gas heat only	0	0.000	25.0
Poughkeepsie	AC with electric heat	1137	0.156	0.0
	AC with gas heat	273	0.156	41.0
	Air source heat pump	916	0.156	0.0
	Electric heat only	959	0.000	0.0
	Gas heat only	0	0.000	41.0
Syracuse	AC with electric heat	1433	0.156	0.0
	AC with gas heat	281	0.156	54.0
	Air source heat pump	1361	0.156	0.0
	Electric heat only	1292	0.000	0.0
	Gas heat only	0	0.000	54.0

High-Performance Windows – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	967	0.156	0.0
	AC with gas heat	239	0.156	34.6
	Air source heat pump	838	0.156	0.0
	Electric heat only	764	0.000	0.0
	Gas heat only	0	0.000	34.6
Binghamton	AC with electric heat	1092	0.156	0.0
	AC with gas heat	200	0.156	40.4
	Air source heat pump	875	0.156	0.0
	Electric heat only	922	0.000	0.0
	Gas heat only	0	0.000	40.4
Buffalo	AC with electric heat	1202	0.156	0.0
	AC with gas heat	233	0.156	48.3
	Air source heat pump	923	0.156	0.0
	Electric heat only	1050	0.000	0.0
	Gas heat only	0	0.000	48.3
Massena	AC with electric heat	1138	0.156	0.0
	AC with gas heat	219	0.156	43.6
	Air source heat pump	980	0.156	0.0
	Electric heat only	943	0.000	0.0
	Gas heat only	0	0.000	43.6
NYC	AC with electric heat	717	0.156	0.0
	AC with gas heat	318	0.156	19.6
	Air source heat pump	613	0.156	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Electric heat only	442	0.000	0.0
	Gas heat only	0	0.000	19.6
Poughkeepsie	AC with electric heat	636	0.156	0.0
	AC with gas heat	216	0.156	19.6
	Air source heat pump	521	0.156	0.0
	Electric heat only	450	0.000	0.0
	Gas heat only	0	0.000	19.6
Syracuse	AC with electric heat	974	0.156	0.0
	AC with gas heat	219	0.156	35.2
	Air source heat pump	837	0.156	0.0
	Electric heat only	781	0.000	0.0
	Gas heat only	0	0.000	35.2

High-Performance Windows –Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1828	0.156	0.0
	AC with gas heat	326	0.156	70.1
	Air source heat pump	1478	0.156	0.0
	Electric heat only	1572	0.000	0.0
	Gas heat only	0	0.000	70.1
Binghamton	AC with electric heat	1863	0.156	0.0
	AC with gas heat	273	0.156	74.2
	Air source heat pump	1580	0.156	0.0
	Electric heat only	1636	0.000	0.0
	Gas heat only	0	0.000	74.2
Buffalo	AC with electric heat	1977	0.156	0.0
	AC with gas heat	298	0.156	78.9
	Air source heat pump	1489	0.156	0.0
	Electric heat only	1714	0.000	0.0
	Gas heat only	0	0.000	78.9
Massena	AC with electric heat	2382	0.156	0.0
	AC with gas heat	319	0.156	95.9
	Air source heat pump	2000	0.156	0.0
	Electric heat only	2130	0.000	0.0
	Gas heat only	0	0.000	95.9
NYC	AC with electric heat	1243	0.156	0.0
	AC with gas heat	413	0.156	40.0
	Air source heat pump	941	0.156	0.0
	Electric heat only	953	0.000	0.0
	Gas heat only	0	0.000	40.0
Poughkeepsie	AC with electric heat	1430	0.156	0.0
	AC with gas heat	312	0.156	53.0
	Air source heat pump	1159	0.156	0.0
	Electric heat only	1202	0.000	0.0
	Gas heat only	0	0.000	53.0
Syracuse	AC with electric heat	1748	0.156	0.0
	AC with gas heat	326	0.156	66.9
	Air source heat pump	1468	0.156	0.0
	Electric heat only	1507	0.000	0.0
	Gas heat only	0	0.000	66.9

High-Performance Windows -Primary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1863	0.000	0.0
	AC with gas heat	554	0.000	57.6
	Air source heat pump	1429	0.000	0.0
	Electric heat only	1332	0.000	0.0
	Gas heat only	0	0.000	57.6
Binghamton	AC with electric heat	1971	0.000	0.0
	AC with gas heat	470	0.000	66.3
	Air source heat pump	1440	0.000	0.0
	Electric heat only	1529	0.000	0.0
	Gas heat only	0	0.000	66.3
Buffalo	AC with electric heat	2195	0.000	0.0
	AC with gas heat	531	0.000	74.0
	Air source heat pump	1556	0.000	0.0
	Electric heat only	1737	0.000	0.0
	Gas heat only	0	0.000	74.0
Massena	AC with electric heat	2072	0.000	0.0
	AC with gas heat	518	0.000	67.7
	Air source heat pump	1636	0.000	0.0
	Electric heat only	1578	0.000	0.0
	Gas heat only	0	0.000	67.7
NYC	AC with electric heat	1671	0.000	0.0
	AC with gas heat	692	0.000	44.4
	Air source heat pump	1174	0.000	0.0
	Electric heat only	1050	0.000	0.0
	Gas heat only	0	0.000	44.4
Poughkeepsie	AC with electric heat	1380	0.000	0.0
	AC with gas heat	570	0.000	35.9
	Air source heat pump	1125	0.000	0.0
	Electric heat only	780	0.000	0.0
	Gas heat only	0	0.000	35.9
Syracuse	AC with electric heat	1958	0.000	0.0
	AC with gas heat	550	0.000	62.3
	Air source heat pump	1468	0.000	0.0
	Electric heat only	1438	0.000	0.0
	Gas heat only	0	0.000	62.3

High-Performance Windows -Religious Worship

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	2222	0.156	0.0
	AC with gas heat	270	0.156	86.5
	Air source heat pump	1951	0.156	0.0
	Electric heat only	1992	0.000	0.0
	Gas heat only	0	0.000	86.5
Binghamton	AC with electric heat	2345	0.156	0.0
	AC with gas heat	220	0.156	96.6
	Air source heat pump	2278	0.156	0.0
	Electric heat only	2163	0.000	0.0
	Gas heat only	0	0.000	96.6
Buffalo	AC with electric heat	2169	0.156	0.0
	AC with gas heat	235	0.156	88.2
	Air source heat pump	1703	0.156	0.0
	Electric heat only	1985	0.000	0.0
	Gas heat only	0	0.000	88.2

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Massena	AC with electric heat	4296	0.156	0.0
	AC with gas heat	304	0.156	182.9
	Air source heat pump	3878	0.156	0.0
	Electric heat only	4083	0.000	0.0
	Gas heat only	0	0.000	182.9
NYC	AC with electric heat	1048	0.156	0.0
	AC with gas heat	389	0.156	30.1
	Air source heat pump	825	0.156	0.0
	Electric heat only	714	0.000	0.0
	Gas heat only	0	0.000	30.1
Poughkeepsie	AC with electric heat	2053	0.156	0.0
	AC with gas heat	262	0.156	83.4
	Air source heat pump	1861	0.156	0.0
	Electric heat only	1843	0.000	0.0
	Gas heat only	0	0.000	83.4
Syracuse	AC with electric heat	1775	0.156	0.0
	AC with gas heat	267	0.156	68.7
	Air source heat pump	1852	0.156	0.0
	Electric heat only	1541	0.000	0.0
	Gas heat only	0	0.000	68.7

High-Performance Windows -Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1169	0.156	0.0
	AC with gas heat	303	0.156	43.1
	Air source heat pump	829	0.156	0.0
	Electric heat only	855	0.000	0.0
	Gas heat only	0	0.000	43.1
Binghamton	AC with electric heat	1225	0.156	0.0
	AC with gas heat	260	0.156	48.2
	Air source heat pump	842	0.156	0.0
	Electric heat only	948	0.000	0.0
	Gas heat only	0	0.000	48.2
Buffalo	AC with electric heat	1300	0.156	0.0
	AC with gas heat	281	0.156	51.0
	Air source heat pump	877	0.156	0.0
	Electric heat only	1024	0.000	0.0
	Gas heat only	0	0.000	51.0
Massena	AC with electric heat	1349	0.156	0.0
	AC with gas heat	290	0.156	51.8
	Air source heat pump	1021	0.156	0.0
	Electric heat only	1052	0.000	0.0
	Gas heat only	0	0.000	51.8
NYC	AC with electric heat	942	0.156	0.0
	AC with gas heat	366	0.156	29.7
	Air source heat pump	639	0.156	0.0
	Electric heat only	581	0.000	0.0
	Gas heat only	0	0.000	29.7
Poughkeepsie	AC with electric heat	860	0.156	0.0
	AC with gas heat	282	0.156	29.0
	Air source heat pump	636	0.156	0.0
	Electric heat only	517	0.000	0.0
	Gas heat only	0	0.000	29.0
Syracuse	AC with electric heat	1201	0.156	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	AC with gas heat	310	0.156	44.7
	Air source heat pump	834	0.156	0.0
	Electric heat only	893	0.000	0.0
	Gas heat only	0	0.000	44.7

High-Performance Windows -Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1704	0.156	0.0
	AC with gas heat	357	0.156	65.4
	Air source heat pump	1259	0.156	0.0
	Electric heat only	1421	0.000	0.0
	Gas heat only	0	0.000	65.4
Binghamton	AC with electric heat	1797	0.156	0.0
	AC with gas heat	320	0.156	72.2
	Air source heat pump	1294	0.156	0.0
	Electric heat only	1559	0.000	0.0
	Gas heat only	0	0.000	72.2
Buffalo	AC with electric heat	1872	0.156	0.0
	AC with gas heat	327	0.156	75.2
	Air source heat pump	1309	0.156	0.0
	Electric heat only	1635	0.000	0.0
	Gas heat only	0	0.000	75.2
Massena	AC with electric heat	1828	0.156	0.0
	AC with gas heat	329	0.156	71.9
	Air source heat pump	1433	0.156	0.0
	Electric heat only	1597	0.000	0.0
	Gas heat only	0	0.000	71.9
NYC	AC with electric heat	1260	0.156	0.0
	AC with gas heat	437	0.156	40.8
	Air source heat pump	886	0.156	0.0
	Electric heat only	929	0.000	0.0
	Gas heat only	0	0.000	40.8
Poughkeepsie	AC with electric heat	1085	0.156	0.0
	AC with gas heat	305	0.156	37.4
	Air source heat pump	821	0.156	0.0
	Electric heat only	819	0.000	0.0
	Gas heat only	0	0.000	37.4
Syracuse	AC with electric heat	1810	0.156	0.0
	AC with gas heat	370	0.156	70.8
	Air source heat pump	1321	0.156	0.0
	Electric heat only	1546	0.000	0.0
	Gas heat only	0	0.000	70.8

High-Performance Windows -Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1828	0.156	0.0
	AC with gas heat	326	0.156	70.1
	Air source heat pump	1478	0.156	0.0
	Electric heat only	1572	0.000	0.0
	Gas heat only	0	0.000	70.1
Binghamton	AC with electric heat	1863	0.156	0.0
	AC with gas heat	273	0.156	74.2
	Air source heat pump	1580	0.156	0.0

Climate	System	kWh/unit	Summer kW/unit	therm/unit
	Electric heat only	1636	0.000	0.0
	Gas heat only	0	0.000	74.2
Buffalo	AC with electric heat	1977	0.156	0.0
	AC with gas heat	298	0.156	78.9
	Air source heat pump	1489	0.156	0.0
	Electric heat only	1714	0.000	0.0
	Gas heat only	0	0.000	78.9
Massena	AC with electric heat	2382	0.156	0.0
	AC with gas heat	319	0.156	95.9
	Air source heat pump	2000	0.156	0.0
	Electric heat only	2130	0.000	0.0
	Gas heat only	0	0.000	95.9
NYC	AC with electric heat	1243	0.156	0.0
	AC with gas heat	413	0.156	40.0
	Air source heat pump	941	0.156	0.0
	Electric heat only	953	0.000	0.0
	Gas heat only	0	0.000	40.0
Poughkeepsie	AC with electric heat	1430	0.156	0.0
	AC with gas heat	312	0.156	53.0
	Air source heat pump	1159	0.156	0.0
	Electric heat only	1202	0.000	0.0
	Gas heat only	0	0.000	53.0
Syracuse	AC with electric heat	1748	0.156	0.0
	AC with gas heat	326	0.156	66.9
	Air source heat pump	1468	0.156	0.0
	Electric heat only	1507	0.000	0.0
	Gas heat only	0	0.000	66.9

WINDOW FILM

Window Film - Assembly

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	388	0.178	-84.0
Binghamton	AC with gas heat	333	0.178	-93.2
Buffalo	AC with gas heat	358	0.178	-82.0
Massena	AC with gas heat	346	0.178	-100.6
NYC	AC with gas heat	592	0.178	-58.3
Poughkeepsie	AC with gas heat	379	0.178	-92.2
Syracuse	AC with gas heat	426	0.178	-66.0

Window Film - Auto Repair

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	167	0.178	-72.4
Binghamton	AC with gas heat	138	0.178	-63.0
buffalo	AC with gas heat	159	0.178	-67.7
Massena	AC with gas heat	155	0.178	-74.0
N YC	AC with gas heat	271	0.178	-77.2
Poughkeepsie	AC with gas heat	164	0.178	-84.3
Syracuse	AC with gas heat	169	0.178	-83.5

Window Film - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	407	0.178	-54.1
Binghamton	AC with gas heat	357	0.178	-57.5
Buffalo	AC with gas heat	378	0.178	-46.4
Massena	AC with gas heat	370	0.178	-58.5
NYC	AC with gas heat	538	0.178	-38.6
Poughkeepsie	AC with gas heat	402	0.178	-47.9
Syracuse	AC with gas heat	402	0.178	-53.6

Window Film - Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	290	0.178	-82.9
Binghamton	AC with gas heat	241	0.178	-84.5
Buffalo	AC with gas heat	263	0.178	-77.3
Massena	AC with gas heat	268	0.178	-85.2
NYC	AC with gas heat	393	0.178	-72.3
Poughkeepsie	AC with gas heat	282	0.178	-85.0
Syracuse	AC with gas heat	297	0.178	-75.9

Window Film - Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	296	0.178	-109.1
Binghamton	AC with gas heat	249	0.178	-111.0
Buffalo	AC with gas heat	265	0.178	-98.9
Massena	AC with gas heat	273	0.178	-109.4
NYC	AC with gas heat	403	0.178	-94.8
Poughkeepsie	AC with gas heat	297	0.178	-110.2
Syracuse	AC with gas heat	309	0.178	-98.3

Window Film - Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	407	0.178	-54.1
Binghamton	AC with gas heat	357	0.178	-57.5
Buffalo	AC with gas heat	378	0.178	-46.4
Massena	AC with gas heat	370	0.178	-58.5
NYC	AC with gas heat	538	0.178	-38.6
Poughkeepsie	AC with gas heat	402	0.178	-47.9
Syracuse	AC with gas heat	402	0.178	-53.6

Window Film – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	232	0.178	-71.6
Binghamton	AC with gas heat	175	0.178	-74.1
Buffalo	AC with gas heat	226	0.178	-62.1
Massena	AC with gas heat	189	0.178	-76.6
NYC	AC with gas heat	251	0.178	-68.4
Poughkeepsie	AC with gas heat	211	0.178	-67.5
Syracuse	AC with gas heat	211	0.178	-65.7

Window Film - Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	445	0.178	-29.0
Binghamton	AC with gas heat	396	0.178	-30.0
Buffalo	AC with gas heat	399	0.178	-27.5
Massena	AC with gas heat	411	0.178	-32.4
NYC	AC with gas heat	523	0.178	-19.8
Poughkeepsie	AC with gas heat	455	0.178	-23.7
Syracuse	AC with gas heat	426	0.178	-27.1

Window Film - Primary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	437	0.000	-105.6
Binghamton	AC with gas heat	300	0.000	-108.8
Buffalo	AC with gas heat	382	0.000	-96.8
Massena	AC with gas heat	383	0.000	-108.7
NYC	AC with gas heat	555	0.000	-98.0
Poughkeepsie	AC with gas heat	437	0.000	-107.6
Syracuse	AC with gas heat	415	0.000	-99.9

Window Film - Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	388	0.178	-84.0
Binghamton	AC with gas heat	333	0.178	-93.2
Buffalo	AC with gas heat	358	0.178	-82.0
Massena	AC with gas heat	346	0.178	-100.6
NYC	AC with gas heat	592	0.178	-58.3
Poughkeepsie	AC with gas heat	379	0.178	-92.2
Syracuse	AC with gas heat	426	0.178	-66.0

Window Film - Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	342	0.178	-73.6
Binghamton	AC with gas heat	307	0.178	-73.9
Buffalo	AC with gas heat	307	0.178	-67.7
Massena	AC with gas heat	290	0.178	-83.6
NYC	AC with gas heat	448	0.178	-62.5
Poughkeepsie	AC with gas heat	319	0.178	-70.8
Syracuse	AC with gas heat	347	0.178	-69.6

Window Film - Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	516	0.178	-88.3
Binghamton	AC with gas heat	421	0.178	-93.5
Buffalo	AC with gas heat	444	0.178	-80.6
Massena	AC with gas heat	462	0.178	-82.0
NYC	AC with gas heat	613	0.178	-83.8
Poughkeepsie	AC with gas heat	509	0.178	-93.1
Syracuse	AC with gas heat	525	0.178	-86.1

Window Film - Other

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	360	0.178	-75.7
Binghamton	AC with gas heat	301	0.178	-78.4
Buffalo	AC with gas heat	326	0.178	-69.6
Massena	AC with gas heat	322	0.178	-80.8
NYC	AC with gas heat	476	0.178	-64.2
Poughkeepsie	AC with gas heat	353	0.178	-76.9
Syracuse	AC with gas heat	363	0.178	-70.4

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APPENDIX G

EQUIVALENT FULL-LOAD HOURS (EFLH), FOR HEATING AND COOLING

Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[67] study, with adjustments made for local building practices and climate.

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

1. Built prior to 1940, uninsulated masonry buildings. This vintage is referred to as "Pre-war uninsulated brick "

2. Built prior to 1979 when the NYS Energy Code (known as the Energy Conservation Construction Code of New York State – ECCCNYS) went into effect, poorly insulated wood-frame buildings This vintage is referred to as "Prior to 1979"

3. Built from 1979 through 2006, with insulation conforming to 1980s era building codes (1979 ECCCNYS.) This vintage is referred to as "From 1979 through 2006."

4. Built from 2007 through the present, new construction with insulation conforming to the 2007 ECCCNYS for residential buildings and the New York City Energy Conservative 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 seven different cities in NY are shown below:

SINGLE-FAMILY DETACHED COOLING EFLH BY VINTAGE AND CITY

City	Old	Average	New
Albany	322	310	279
Binghamton	199	197	158
Buffalo	334	322	276
Massena	258	250	210
Poughkeepsie	496	470	464
NYC	670	630	649
Syracuse	310	296	268

67 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

MULTI-FAMILY LOW-RISE COOLING EFLH BY VINTAGE AND CITY

City	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	286	295	279
Binghamton	217	219	210
Buffalo	270	274	256
Massena	230	228	218
NYC	507	550	562
Poughkeepsie	397	423	421
Syracuse	265	284	297

MULTI-FAMILY HIGH-RISE COOLING EFLH BY VINTAGE AND CITY[68]

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

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 are shown below:

SINGLE-FAMILY DETACHED HEATING EFLH BY VINTAGE AND CITY

City	Old	Average	New
Albany	1,469	1,379	1,304
Binghamton	1,531	1,450	1,357
Buffalo	1,530	1,473	1,366
Massena	1,586	1,496	1,422
NYC	1,030	934	861
Poughkeepsie	1,250	1,157	1,083
Syracuse	1,466	1,391	1,298

[68] Note, there are no cooling values for the "Pre-war uninsulated brick vintage, due to a typical lack of any central cooling. This vintage assumes one room air conditioner (RAC) within the unit. For the savings calculation method, see the Air Conditioner – Room (RAC) measure listed in the Single and Multi-family Residential Measures section of this manual.

MULTI-FAMILY LOW-RISE HEATING EFLH BY VINTAGE AND CITY

City	Pre-war uninsulated brick	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	1,111	1,030	1,012	729
Binghamton	1,397	1,320	1,245	899
Buffalo	1,281	1,219	1,215	883
Massena	1,433	1,306	1,326	964
NYC[69]	999	757	723	503
Poughkeepsie	857	894	868	616
Syracuse	1,395	1,175	1,206	845

MULTI-FAMILY HIGH-RISE HEATING EFLH BY VINTAGE AND CITY

City	Pre-war uninsulated brick	Prior to 1979	From 1979 Through 2006	From 2007 Through the Present
Albany	975	786	626	363
Binghamton	1,102	1,006	831	484
Buffalo	1,181	966	813	471
Massena	1,111	1,016	873	552
NYC[70]	1,012	526	395	219
Poughkeepsie	922	656	510	291
Syracuse	1,063	889	787	474

[69] NYC building only incorporates a higher thermostatic set point of 73°F instead of 70 °F based on reported data. The other cities listed use the thermostatic set-point of 7070⁰ F. Overheating in Hot Water and Steam-Heated Multi-family Buildings, U.S. Dept. of Energy, Jordan Dentz, Kapil Varshney and Hugh Henderson, October 2013.
[70] IBID

SMALL COMMERCIAL COOLING EFLH

Building	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Assembly	478	436	497	415	669	574	506
Auto Repair	272	244	264	223	426	302	298
Big Box Retail	769	760	826	688	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	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Community College	CAV econ	585	433	520	509	846	706	609
	CAV noecon	773	586	693	692	1,128	997	811
	VAV econ	470	376	456	353	658	532	455
Dormitory[71]	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

[71] Dormitories consist of individual rooms with small heating/cooling coils. Constant Air Volume (CAV) or Variable Air Volume (VAV) with Economizers (econ) are not typically used.

Building	System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
	CAV noecon	1,656	1,613	1,763	1,545	1,751	1,670	1,656
	VAV econ	704	594	713	611	886	757	704
University	CAV econ	680	496	610	567	882	706	699
	CAV noecon	936	723	870	811	1,208	1,030	951
	VAV econ	526	432	518	413	690	568	523

Small Commercial Heating EFLH

Building	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Assembly	961	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	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Community College	CAV econ	1,111	1,072	1,047	1,301	1,431	1,171	1,259
	CAV noecon	1,052	1,042	1,006	1,177	1,268	1,050	1,177
	VAV econ	607	1,161	1,040	606	434	389	554
Dormitory*	Fan Coil*	594	678	753	687	465	507	673
High School	CAV econ	776	782	808	822	901	898	960
	CAV noecon	701	725	741	759	840	829	902
	VAV econ	326	300	384	382	268	303	395
Hospital	CAV econ	3,084	2,847	2,897	2,782	3,366	2,886	3,062
	CAV noecon	2,733	2,423	2,516	2,353	3,137	2,514	2,704
	VAV econ	763	766	642	739	296	481	771
Hotel	CAV econ	1,230	1,177	1,220	1,239	1,077	1,054	1,175
	CAV noecon	962	907	941	1,032	753	794	919
	VAV econ	552	482	518	661	229	376	464
Large Office	CAV econ	2,136	2,047	2,020	2,349	2,034	2,142	2,218

Building	System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
	CAV noecon	2,097	1,965	1,976	2,307	2,072	2,133	2,219
	VAV econ	484	476	485	544	291	367	441
Large Retail	CAV econ	2,167	2,148	2,147	2,243	2,101	2,030	2,144
	CAV noecon	2,057	1,983	2,015	2,106	2,033	1,913	2,030
	VAV econ	859	735	777	927	664	632	783
University	CAV econ	1,464	1,573	1,531	1,589	1,191	1,352	1,390
	CAV noecon	1,439	1,438	1,461	1,456	1,104	1,308	1,356
	VAV econ	1,060	569	1,206	1,224	684	761	624

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APPENDIX H

HVAC DISTRIBUTION EFFICIENCIES

Single-family Distribution System Efficiency in Heating Mode, Ducts Located in Unconditioned Basement

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.951	0.946	0.947	0.949	0.957	0.949
15%	Uninsulated	0.941	0.936	0.939	0.940	0.946	0.941
20%	Uninsulated	0.936	0.931	0.932	0.933	0.939	0.934
25%	Uninsulated	0.929	0.924	0.925	0.928	0.934	0.929
30%	Uninsulated	0.924	0.919	0.920	0.922	0.926	0.922
8%	R-6	0.980	0.979	0.978	0.978	0.980	0.979
15%	R-6	0.968	0.967	0.967	0.967	0.969	0.967
20%	R-6	0.959	0.959	0.959	0.960	0.962	0.960
25%	R-6	0.953	0.952	0.952	0.951	0.954	0.951
30%	R-6	0.946	0.944	0.944	0.944	0.946	0.944

Single-family Distribution System Efficiency in Cooling Mode, Ducts Located in Unconditioned Basement

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.969	0.964	0.958	0.974	0.973	0.975
15%	Uninsulated	0.959	0.952	0.952	0.974	0.967	0.967
20%	Uninsulated	0.956	0.945	0.946	0.968	0.959	0.961
25%	Uninsulated	0.948	0.939	0.938	0.966	0.955	0.956
30%	Uninsulated	0.946	0.938	0.934	0.960	0.948	0.950
8%	R-6	0.985	0.987	0.982	0.985	0.987	0.987
15%	R-6	0.972	0.976	0.968	0.976	0.976	0.977
20%	R-6	0.966	0.964	0.959	0.965	0.970	0.972
25%	R-6	0.960	0.961	0.954	0.959	0.967	0.966
30%	R-6	0.956	0.957	0.948	0.965	0.958	0.960

Residential Distribution System Efficiency in Heating Mode (Attic Ducts)

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse	Poughkeepsie
8%	Uninsulated	0.777	0.754	0.770	0.759	0.818	0.778	0.779
15%	Uninsulated	0.715	0.692	0.708	0.693	0.761	0.716	0.717
20%	Uninsulated	0.668	0.646	0.662	0.644	0.717	0.670	0.671
25%	Uninsulated	0.619	0.599	0.614	0.592	0.673	0.622	0.623
30%	Uninsulated	0.568	0.549	0.564	0.539	0.626	0.571	0.573
8%	R-6	0.910	0.907	0.910	0.905	0.920	0.911	0.911
15%	R-6	0.851	0.848	0.851	0.843	0.865	0.852	0.851
20%	R-6	0.806	0.804	0.807	0.796	0.823	0.808	0.807
25%	R-6	0.760	0.759	0.762	0.748	0.780	0.762	0.761
30%	R-6	0.712	0.711	0.715	0.698	0.735	0.714	0.714

Residential Distribution System Efficiency in Cooling Mode (Attic Ducts)

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse	Poughkeepsie
8%	Uninsulated	0.813	0.793	0.820	0.809	0.834	0.811	0.810
15%	Uninsulated	0.755	0.737	0.768	0.753	0.777	0.758	0.753
20%	Uninsulated	0.716	0.698	0.732	0.715	0.737	0.717	0.713
25%	Uninsulated	0.676	0.660	0.694	0.673	0.696	0.677	0.672
30%	Uninsulated	0.637	0.621	0.656	0.634	0.657	0.637	0.632
8%	R-6	0.916	0.914	0.922	0.916	0.919	0.918	0.916
15%	R-6	0.860	0.860	0.870	0.859	0.861	0.862	0.861
20%	R-6	0.821	0.820	0.833	0.819	0.823	0.821	0.821
25%	R-6	0.780	0.780	0.795	0.781	0.782	0.783	0.780
30%	R-6	0.740	0.740	0.761	0.739	0.741	0.742	0.739

Multi-family Distribution System Efficiency in Heating Mode

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.821	0.817	0.819	0.813	0.843	0.822
15%	Uninsulated	0.794	0.791	0.793	0.785	0.816	0.795
20%	Uninsulated	0.774	0.773	0.774	0.765	0.797	0.775
25%	Uninsulated	0.754	0.754	0.755	0.744	0.778	0.756
30%	Uninsulated	0.735	0.736	0.735	0.724	0.758	0.736
8%	R-6	0.943	0.944	0.944	0.941	0.949	0.944
15%	R-6	0.913	0.915	0.915	0.909	0.920	0.914
20%	R-6	0.892	0.895	0.894	0.887	0.900	0.893
25%	R-6	0.870	0.874	0.873	0.864	0.879	0.871
30%	R-6	0.848	0.853	0.852	0.841	0.858	0.849

Multi-family Distribution System Efficiency in Cooling Mode

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.814	0.797	0.821	0.805	0.859	0.808
15%	Uninsulated	0.792	0.774	0.799	0.776	0.838	0.782
20%	Uninsulated	0.770	0.750	0.781	0.759	0.824	0.767
25%	Uninsulated	0.757	0.739	0.762	0.744	0.810	0.752
30%	Uninsulated	0.738	0.720	0.748	0.726	0.795	0.734
8%	R-6	0.941	0.936	0.945	0.938	0.951	0.939
15%	R-6	0.912	0.909	0.916	0.913	0.929	0.910
20%	R-6	0.893	0.890	0.899	0.889	0.911	0.888
25%	R-6	0.871	0.870	0.879	0.870	0.894	0.870
30%	R-6	0.852	0.851	0.863	0.849	0.876	0.851

Assembly Building Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.909	0.923	0.918	0.925	0.857	0.881
15%	Uninsulated	0.879	0.890	0.889	0.890	0.829	0.851
20%	Uninsulated	0.858	0.868	0.867	0.869	0.810	0.831
25%	Uninsulated	0.835	0.848	0.846	0.849	0.793	0.812
30%	Uninsulated	0.816	0.829	0.828	0.829	0.776	0.795
8%	R-6	0.951	0.961	0.959	0.956	0.896	0.915
15%	R-6	0.917	0.930	0.926	0.923	0.863	0.883
20%	R-6	0.895	0.906	0.902	0.901	0.841	0.861
25%	R-6	0.871	0.884	0.879	0.881	0.821	0.840
30%	R-6	0.849	0.862	0.860	0.862	0.801	0.819

Assembly Building Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.870	0.845	0.857	0.869	0.922	0.898
15%	Uninsulated	0.859	0.835	0.846	0.858	0.908	0.887
20%	Uninsulated	0.850	0.825	0.838	0.850	0.897	0.878
25%	Uninsulated	0.840	0.815	0.828	0.840	0.886	0.867
30%	Uninsulated	0.829	0.805	0.817	0.829	0.873	0.856
8%	R-6	0.948	0.930	0.936	0.951	0.986	0.980
15%	R-6	0.932	0.916	0.921	0.936	0.967	0.964
20%	R-6	0.920	0.904	0.909	0.924	0.954	0.951
25%	R-6	0.906	0.891	0.896	0.910	0.939	0.938
30%	R-6	0.892	0.877	0.882	0.896	0.924	0.923

Fast Food Restaurant Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.809	0.807	0.804	0.820	0.766	0.805
15%	Uninsulated	0.784	0.784	0.781	0.797	0.734	0.778
20%	Uninsulated	0.766	0.768	0.765	0.780	0.714	0.759
25%	Uninsulated	0.750	0.753	0.749	0.765	0.693	0.742
30%	Uninsulated	0.734	0.739	0.734	0.750	0.675	0.725
8%	R-6	0.901	0.904	0.901	0.905	0.875	0.898
15%	R-6	0.862	0.867	0.864	0.867	0.825	0.858
20%	R-6	0.836	0.844	0.840	0.844	0.794	0.831
25%	R-6	0.813	0.822	0.817	0.822	0.765	0.806
30%	R-6	0.791	0.801	0.796	0.801	0.739	0.783

Fast Food Restaurant Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.853	0.843	0.853	0.845	0.866	0.848
15%	Uninsulated	0.843	0.834	0.843	0.837	0.853	0.839
20%	Uninsulated	0.836	0.827	0.835	0.830	0.844	0.831
25%	Uninsulated	0.827	0.819	0.827	0.822	0.834	0.823
30%	Uninsulated	0.818	0.810	0.817	0.814	0.823	0.814
8%	R-6	0.950	0.950	0.953	0.948	0.945	0.947
15%	R-6	0.933	0.935	0.937	0.932	0.925	0.930
20%	R-6	0.921	0.924	0.925	0.919	0.911	0.917
25%	R-6	0.908	0.912	0.912	0.907	0.896	0.904
30%	R-6	0.895	0.899	0.898	0.894	0.881	0.891

Full Service Restaurant Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.816	0.821	0.816	0.819	0.797	0.810
15%	Uninsulated	0.789	0.797	0.791	0.794	0.765	0.782
20%	Uninsulated	0.770	0.781	0.775	0.776	0.743	0.763
25%	Uninsulated	0.753	0.765	0.760	0.759	0.721	0.745
30%	Uninsulated	0.736	0.750	0.745	0.744	0.701	0.728
8%	R-6	0.904	0.910	0.905	0.902	0.893	0.901
15%	R-6	0.866	0.876	0.869	0.866	0.848	0.861
20%	R-6	0.840	0.853	0.847	0.841	0.818	0.834
25%	R-6	0.816	0.832	0.825	0.818	0.789	0.809
30%	R-6	0.794	0.812	0.805	0.797	0.763	0.786

Full Service Restaurant Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.827	0.827	0.840	0.814	0.854	0.821
15%	Uninsulated	0.825	0.826	0.839	0.813	0.845	0.819
20%	Uninsulated	0.821	0.824	0.836	0.811	0.837	0.815
25%	Uninsulated	0.818	0.821	0.832	0.808	0.829	0.812
30%	Uninsulated	0.813	0.817	0.827	0.804	0.820	0.807
8%	R-6	0.959	0.968	0.975	0.955	0.954	0.957
15%	R-6	0.955	0.970	0.975	0.953	0.941	0.952
20%	R-6	0.950	0.968	0.971	0.948	0.931	0.947
25%	R-6	0.943	0.963	0.966	0.942	0.919	0.940
30%	R-6	0.934	0.957	0.958	0.934	0.907	0.931

Small Retail Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.657	0.646	0.648	0.670	0.614	0.656
15%	Uninsulated	0.624	0.614	0.617	0.637	0.581	0.623
20%	Uninsulated	0.602	0.594	0.596	0.615	0.559	0.601
25%	Uninsulated	0.582	0.574	0.577	0.594	0.538	0.581
30%	Uninsulated	0.563	0.556	0.559	0.575	0.520	0.562
8%	R-6	0.792	0.787	0.788	0.798	0.767	0.789
15%	R-6	0.742	0.736	0.739	0.748	0.714	0.738
20%	R-6	0.710	0.704	0.707	0.716	0.679	0.705
25%	R-6	0.680	0.674	0.678	0.686	0.648	0.676
30%	R-6	0.652	0.646	0.652	0.659	0.619	0.648

Small Retail Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.825	0.822	0.825	0.816	0.838	0.817
15%	Uninsulated	0.818	0.817	0.819	0.809	0.827	0.810
20%	Uninsulated	0.812	0.812	0.813	0.804	0.818	0.804
25%	Uninsulated	0.805	0.806	0.807	0.798	0.809	0.797
30%	Uninsulated	0.798	0.800	0.800	0.791	0.799	0.790
8%	R-6	0.932	0.934	0.935	0.927	0.931	0.928
15%	R-6	0.921	0.926	0.924	0.917	0.915	0.916
20%	R-6	0.912	0.918	0.916	0.908	0.904	0.907
25%	R-6	0.903	0.910	0.907	0.899	0.891	0.897
30%	R-6	0.892	0.902	0.897	0.889	0.879	0.887

Other Building Distribution Efficiency Heating

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.798	0.799	0.797	0.809	0.759	0.788
15%	Uninsulated	0.769	0.771	0.770	0.780	0.727	0.759
20%	Uninsulated	0.749	0.753	0.751	0.760	0.707	0.739
25%	Uninsulated	0.730	0.735	0.733	0.742	0.686	0.720
30%	Uninsulated	0.712	0.719	0.717	0.725	0.668	0.703
8%	R-6	0.887	0.891	0.888	0.890	0.858	0.876
15%	R-6	0.847	0.852	0.850	0.851	0.813	0.835
20%	R-6	0.820	0.827	0.824	0.826	0.783	0.808
25%	R-6	0.795	0.803	0.800	0.802	0.756	0.783
30%	R-6	0.772	0.780	0.778	0.780	0.731	0.759

Other Building Distribution Efficiency Cooling

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.844	0.834	0.844	0.836	0.870	0.846
15%	Uninsulated	0.836	0.828	0.837	0.829	0.858	0.839
20%	Uninsulated	0.830	0.822	0.831	0.824	0.849	0.832
25%	Uninsulated	0.823	0.815	0.824	0.817	0.840	0.825
30%	Uninsulated	0.815	0.808	0.815	0.810	0.829	0.817
8%	R-6	0.947	0.946	0.950	0.945	0.954	0.953
15%	R-6	0.935	0.937	0.939	0.935	0.937	0.941
20%	R-6	0.926	0.929	0.930	0.925	0.925	0.931
25%	R-6	0.915	0.919	0.920	0.915	0.911	0.920
30%	R-6	0.903	0.909	0.909	0.903	0.898	0.908

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
7-13-27	7/31/2013

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APPENDIX I

COOL ROOF

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Assembly	Albany	1,000 sq ft roof area	138	0.128	-16.0
	Binghamton	1,000 sq ft roof area	123	0.128	-16.0
	Buffalo	1,000 sq ft roof area	119	0.128	-16.0
	Massena	1,000 sq ft roof area	135	0.128	-19.0
	NYC	1,000 sq ft roof area	168	0.128	-11.0
	Poughkeepsie	1,000 sq ft roof area	163	0.128	-13.5
	Syracuse	1,000 sq ft roof area	150	0.128	-18.0
Auto Repair	Albany	1,000 sq ft roof area	77	0.128	-23.0
	Binghamton	1,000 sq ft roof area	66	0.128	-20.2
	Buffalo	1,000 sq ft roof area	65	0.128	-20.0
	Massena	1,000 sq ft roof area	78	0.128	-23.3
	NYC	1,000 sq ft roof area	116	0.128	-20.8
	Poughkeepsie	1,000 sq ft roof area	95	0.128	-21.9
	Syracuse	1,000 sq ft roof area	89	0.128	-21.9
Big Box Retail	Albany	1,000 sq ft roof area	155	0.128	-11.0
	Binghamton	1,000 sq ft roof area	146	0.128	-10.5
	Buffalo	1,000 sq ft roof area	132	0.128	-10.0
	Massena	1,000 sq ft roof area	150	0.128	-14.0
	NYC	1,000 sq ft roof area	187	0.128	-6.0
	Poughkeepsie	1,000 sq ft roof area	183	0.128	-8.5
	Syracuse	1,000 sq ft roof area	165	0.128	-12.0
Fast Food	Albany	1,000 sq ft roof area	117	0.128	-28.0
	Binghamton	1,000 sq ft roof area	101	0.128	-26.0
	Buffalo	1,000 sq ft roof area	101	0.128	-24.0
	Massena	1,000 sq ft roof area	124	0.128	-25.0
	NYC	1,000 sq ft roof area	170	0.128	-19.0
	Poughkeepsie	1,000 sq ft roof area	143	0.128	-23.5
	Syracuse	1,000 sq ft roof area	131	0.128	-28.0
Full Service Restaurant	Albany	1,000 sq ft roof area	279	0.128	-47.0
	Binghamton	1,000 sq ft roof area	112	0.128	-43.5
	Buffalo	1,000 sq ft roof area	233	0.128	-40.0
	Massena	1,000 sq ft roof area	282	0.128	-47.0
	NYC	1,000 sq ft roof area	344	0.128	-30.0
	Poughkeepsie	1,000 sq ft roof area	160	0.128	-38.5
	Syracuse	1,000 sq ft roof area	307	0.128	-47.0
Grocery	Albany	1,000 sq ft roof area	155	0.128	-11.0
	Binghamton	1,000 sq ft roof area	146	0.128	-10.5
	Buffalo	1,000 sq ft roof area	132	0.128	-10.0
	Massena	1,000 sq ft roof area	150	0.128	-14.0
	NYC	1,000 sq ft roof area	187	0.128	-6.0
	Poughkeepsie	1,000 sq ft roof area	183	0.128	-8.5
	Syracuse	1,000 sq ft roof area	165	0.128	-12.0

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Light Industrial	Albany	1,000 sq ft roof area	90	0.128	-20.0
	Binghamton	1,000 sq ft roof area	62	0.128	-19.0
	Buffalo	1,000 sq ft roof area	74	0.128	-18.0
	Massena	1,000 sq ft roof area	87	0.128	-21.0
	NYC	1,000 sq ft roof area	118	0.128	-14.0
	Poughkeepsie	1,000 sq ft roof area	94	0.128	-17.0
	Syracuse	1,000 sq ft roof area	102	0.128	-20.0
Motel	Albany	1,000 sq ft roof area	225	0.128	-10.0
	Binghamton	1,000 sq ft roof area	196	0.128	-8.8
	Buffalo	1,000 sq ft roof area	224	0.128	-11.3
	Massena	1,000 sq ft roof area	238	0.128	-6.3
	NYC	1,000 sq ft roof area	232	0.128	-10.9
	Poughkeepsie	1,000 sq ft roof area	207	0.128	-11.1
	Syracuse	1,000 sq ft roof area	250	0.128	-11.0
Primary School	Albany	1,000 sq ft roof area	196	0.624	-29.0
	Binghamton	1,000 sq ft roof area	145	0.086	-28.0
	Buffalo	1,000 sq ft roof area	152	0.426	-27.0
	Massena	1,000 sq ft roof area	191	0.116	-32.0
	NYC	1,000 sq ft roof area	270	0.652	-22.0
	Poughkeepsie	1,000 sq ft roof area	225	0.474	-25.5
	Syracuse	1,000 sq ft roof area	202	0.506	-33.0
Religious	Albany	1,000 sq ft roof area	138	0.128	-16.0
	Binghamton	1,000 sq ft roof area	123	0.128	-18.0
	Buffalo	1,000 sq ft roof area	120	0.128	-15.6
	Massena	1,000 sq ft roof area	135	0.128	-19.5
	NYC	1,000 sq ft roof area	168	0.128	-10.3
	Poughkeepsie	1,000 sq ft roof area	163	0.128	-19.7
	Syracuse	1,000 sq ft roof area	150	0.128	-18.8
Small Office	Albany	1,000 sq ft roof area	151	0.128	-12.0
	Binghamton	1,000 sq ft roof area	128	0.128	-11.5
	Buffalo	1,000 sq ft roof area	130	0.128	-11.0
	Massena	1,000 sq ft roof area	152	0.128	-14.0
	NYC	1,000 sq ft roof area	169	0.128	-8.0
	Poughkeepsie	1,000 sq ft roof area	164	0.128	-10.0
	Syracuse	1,000 sq ft roof area	157	0.128	-14.0
Small Retail	Albany	1,000 sq ft roof area	175	0.128	-17.0
	Binghamton	1,000 sq ft roof area	160	0.128	-16.0
	Buffalo	1,000 sq ft roof area	143	0.128	-15.0
	Massena	1,000 sq ft roof area	164	0.128	-21.0
	NYC	1,000 sq ft roof area	203	0.128	-12.0
	Poughkeepsie	1,000 sq ft roof area	195	0.128	-14.5
	Syracuse	1,000 sq ft roof area	184	0.128	-18.0
Warehouse	Albany	1,000 sq ft roof area	393	0.128	-48.4
	Binghamton	1,000 sq ft roof area	324	0.128	-56.4
	Buffalo	1,000 sq ft roof area	300	0.128	-44.7
	Massena	1,000 sq ft roof area	402	0.128	-47.4
	NYC	1,000 sq ft roof area	454	0.128	-38.6
	Poughkeepsie	1,000 sq ft roof area	464	0.128	-63.7
	Syracuse	1,000 sq ft roof area	440	0.128	-52.2

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Other	Albany	1,000 sq ft roof area	188	0.128	-25.0
	Binghamton	1,000 sq ft roof area	142	0.128	-21.9
	Buffalo	1,000 sq ft roof area	149	0.128	-20.2
	Massena	1,000 sq ft roof area	175	0.128	-23.0
	NYC	1,000 sq ft roof area	211	0.128	-16.7
	Poughkeepsie	1,000 sq ft roof area	188	0.128	-21.0
	Syracuse	1,000 sq ft roof area	193	0.128	-23.3

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010

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APPENDIX J

COMMERCIAL HVAC UNIT SAVINGS

AIR SIDE ECONOMIZER

Building Type	City	System Type	Unit	KWh/unit
Assembly	Albany	Air-Side Economizer	ton	39
	Binghamton	Air-Side Economizer	ton	36
	Buffalo	Air-Side Economizer	ton	45
	Massena	Air-Side Economizer	ton	33
	NYC	Air-Side Economizer	ton	27
	Syracuse	Air-Side Economizer	ton	42
	Poughkeepsie	Air-Side Economizer	ton	33
Big Box Retail	Albany	Air-Side Economizer	ton	165
	Binghamton	Air-Side Economizer	ton	152
	Buffalo	Air-Side Economizer	ton	167
	Massena	Air-Side Economizer	ton	138
	NYC	Air-Side Economizer	ton	152
	Syracuse	Air-Side Economizer	ton	165
	Poughkeepsie	Air-Side Economizer	ton	159
Fast Food	Albany	Air-Side Economizer	ton	49
	Binghamton	Air-Side Economizer	ton	47
	Buffalo	Air-Side Economizer	ton	53
	Massena	Air-Side Economizer	ton	44
	NYC	Air-Side Economizer	ton	39
	Syracuse	Air-Side Economizer	ton	49
	Poughkeepsie	Air-Side Economizer	ton	44
Full Service Restaurant	Albany	Air-Side Economizer	ton	38
	Binghamton	Air-Side Economizer	ton	35
	Buffalo	Air-Side Economizer	ton	41
	Massena	Air-Side Economizer	ton	32
	NYC	Air-Side Economizer	ton	31
	Syracuse	Air-Side Economizer	ton	38
	Poughkeepsie	Air-Side Economizer	ton	35
Light Industrial	Albany	Air-Side Economizer	ton	45
	Binghamton	Air-Side Economizer	ton	39
	Buffalo	Air-Side Economizer	ton	38
	Massena	Air-Side Economizer	ton	33
	NYC	Air-Side Economizer	ton	25
	Syracuse	Air-Side Economizer	ton	54
	Poughkeepsie	Air-Side Economizer	ton	35
Primary School	Albany	Air-Side Economizer	ton	49
	Binghamton	Air-Side Economizer	ton	44
	Buffalo	Air-Side Economizer	ton	52
	Massena	Air-Side Economizer	ton	38
	NYC	Air-Side Economizer	ton	42
	Syracuse	Air-Side Economizer	ton	41
	Poughkeepsie	Air-Side Economizer	ton	46
Small Office	Albany	Air-Side Economizer	ton	202
	Binghamton	Air-Side Economizer	ton	195
	Buffalo	Air-Side Economizer	ton	195

Building Type	City	System Type	Unit	KWh/unit
	Massena	Air-Side Economizer	ton	188
	NYC	Air-Side Economizer	ton	186
	Syracuse	Air-Side Economizer	ton	186
	Poughkeepsie	Air-Side Economizer	ton	194
Small Retail	Albany	Air-Side Economizer	ton	107
	Binghamton	Air-Side Economizer	ton	101
	Buffalo	Air-Side Economizer	ton	113
	Massena	Air-Side Economizer	ton	95
	NYC	Air-Side Economizer	ton	95
	Syracuse	Air-Side Economizer	ton	111
	Poughkeepsie	Air-Side Economizer	ton	101
Religious	Albany	Air-Side Economizer	ton	9
	Binghamton	Air-Side Economizer	ton	10
	Buffalo	Air-Side Economizer	ton	7
	Massena	Air-Side Economizer	ton	6
	NYC	Air-Side Economizer	ton	6
	Syracuse	Air-Side Economizer	ton	6
	Poughkeepsie	Air-Side Economizer	ton	7
Warehouse	Albany	Air-Side Economizer	ton	3
	Binghamton	Air-Side Economizer	ton	5
	Buffalo	Air-Side Economizer	ton	2
	Massena	Air-Side Economizer	ton	4
	NYC	Air-Side Economizer	ton	2
	Syracuse	Air-Side Economizer	ton	7
	Poughkeepsie	Air-Side Economizer	ton	4
Other	Albany	Air-Side Economizer	ton	71
	Binghamton	Air-Side Economizer	ton	66
	Buffalo	Air-Side Economizer	ton	71
	Massena	Air-Side Economizer	ton	61
	NYC	Air-Side Economizer	ton	61
	Syracuse	Air-Side Economizer	ton	70
	Poughkeepsie	Air-Side Economizer	ton	66

CLOSE APPROACH COOLING TOWERS

Building Type	City	System Type	kWh/ton	kW/ton
Dormitory	Albany	Fan coil with Water Cooled Chiller	6.7	0.003
	Buffalo	Fan coil with Water Cooled Chiller	5.6	0.004
	Massena	Fan coil with Water Cooled Chiller	5.9	0.047
	NYC	Fan coil with Water Cooled Chiller	7.7	-0.006
	Syracuse	Fan coil with Water Cooled Chiller	6.8	0.003
	Binghamton	Fan coil with Water Cooled Chiller	5.5	0.003
	Poughkeepsie	Fan coil with Water Cooled Chiller	8.0	0.003

ECONOMIZER

Building Type	City	System type	kWh/ton	kW/ton
High School	Albany	CV no econ	5.7	0
		CV econ	1.8	0
		VAV econ	2.3	0
	Binghamton	CV no econ	5.9	0
		CV econ	2.2	0
		VAV econ	2.4	0
	Buffalo	CV no econ	5.6	0
		CV econ	1.8	0
		VAV econ	1.8	0
	Massena	CV no econ	5.9	0
		CV econ	1.8	0
		VAV econ	1.8	0
	NYC	CV no econ	6.3	0
		CV econ	2.3	0
		VAV econ	3.2	0
	Syracuse	CV no econ	5.9	0
		CV econ	2.2	0
		VAV econ	2.4	0
	Poughkeepsie	CV no econ	5.9	0
		CV econ	2.2	0
		VAV econ	2.4	0
Hotel	Albany	CV no econ	11.8	0
		CV econ	2.8	0
		VAV econ	3.5	0
	Binghamton	CV no econ	12.4	0
		CV econ	3.0	0
		VAV econ	3.5	0
	Buffalo	CV no econ	14.0	0
		CV econ	3.4	0
		VAV econ	3.6	0
	Massena	CV no econ	10.4	0
		CV econ	3.1	0
		VAV econ	3.9	0
	NYC	CV no econ	10.4	0
		CV econ	3.1	0
		VAV econ	3.9	0
	Syracuse	CV no econ	12.9	0
		CV econ	3.1	0
		VAV econ	3.6	0
	Poughkeepsie	CV no econ	11.1	0
		CV econ	3.0	0
		VAV econ	11.8	0

Building Type	City	System type	kWh/ton	kW/ton
Large Office	Albany	CV no econ	12.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	Binghamton	CV no econ	11.0	0
		CV econ	5.0	0
		VAV econ	5.0	0
	Buffalo	CV no econ	11.0	0
		CV econ	5.0	0
		VAV econ	6.0	0
	Massena	CV no econ	12.0	0
		CV econ	5.0	0
		VAV econ	5.0	0
	NYC	CV no econ	14.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	Syracuse	CV no econ	11.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	Poughkeepsie	CV no econ	13.0	0
		CV econ	5.0	0
		VAV econ	7.0	0
	Albany	CV no econ	14.0	0
		CV econ	9.0	0
		VAV econ	7.0	0
	Binghamton	CV no econ	14.0	0
		CV econ	8.0	0
		VAV econ	6.0	0
	Buffalo	CV no econ	14.0	0
		CV econ	8.0	0
		VAV econ	6.0	0
	Massena	CV no econ	13.0	0
		CV econ	8.0	0
		VAV econ	6.0	0
	NYC	CV no econ	16.0	0
		CV econ	10.0	0
		VAV econ	7.0	0
	Syracuse	CV no econ	14.0	0
		CV econ	9.0	0
		VAV econ	6.0	0
	Poughkeepsie	CV no econ	15.0	0
		CV econ	9.5	0
		VAV econ	7.0	0

Building Type	City	System type	kWh/ton	kW/ton
Large Retail	Albany	CV no econ	9.3	0
		CV econ	4.2	0
		VAV econ	6.3	0
	Binghamton	CV no econ	9.6	0
		CV econ	3.8	0
		VAV econ	4.9	0
	Buffalo	CV no econ	9.5	0
		CV econ	4.3	0
		VAV econ	5.6	0
	Massena	CV no econ	9.1	0
		CV econ	3.8	0
		VAV econ	6.0	0
	NYC	CV no econ	10.9	0
		CV econ	4.8	0
		VAV econ	8.6	0
	Syracuse	CV no econ	9.1	0
		CV econ	4.0	0
		VAV econ	7.3	0
	Poughkeepsie	CV no econ	9.8	0
		CV econ	4.2	0
		VAV econ	7.1	0
University	Albany	CV no econ	5.6	0
		CV econ	3.6	0
		VAV econ	4.1	0
	Binghamton	CV no econ	5.0	0
		CV econ	3.2	0
		VAV econ	3.3	0
	Buffalo	CV no econ	5.0	0
		CV econ	3.1	0
		VAV econ	3.8	0
	Massena	CV no econ	5.1	0
		CV econ	3.0	0
		VAV econ	3.8	0
	NYC	CV no econ	6.6	0
		CV econ	3.9	0
		VAV econ	5.7	0
	Syracuse	CV no econ	5.4	0
		CV econ	3.5	0
		VAV econ	4.1	0
	Poughkeepsie	CV no econ	6.7	0
		CV econ	3.6	0
		VAV econ	4.5	0

Building Type	City	System type	kWh/ton	kW/ton
Other	Albany	CV no econ	9.7	0
		CV econ	4.4	0
		VAV econ	5.0	0
	Binghamton	CV no econ	9.6	0
		CV econ	4.2	0
		VAV econ	4.2	0
	Buffalo	CV no econ	9.9	0
		CV econ	4.3	0
		VAV econ	4.5	0
	Massena	CV no econ	9.3	0
		CV econ	4.1	0
		VAV econ	4.4	0
	NYC	CV no econ	10.7	0
		CV econ	4.9	0
		VAV econ	5.9	0
	Syracuse	CV no econ	9.7	0
		CV econ	4.5	0
		VAV econ	5.1	0
	Poughkeepsie	CV no econ	10.3	0
		CV econ	4.6	0
		VAV econ	5.3	0

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APPENDIX K

VARIABLE FREQUENCY DRIVES

Unit energy (kWh) savings for VFDs were estimated by building type, HVAC type and city using DOE-2.2 simulations of the prototype buildings with built-up HVAC systems. The simulations were run for each of the three built-up system types (CV no economizer, CV with economizer, and VAV with economizer) and the results were weighted according to the HVAC system weights shown in Appendix B. The results for each prototype are shown by measure and location below:

Hotel

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	73	1740	6559	326	250	1571
Binghamton	73	1745	6554	284	211	1423
Buffalo	75	1764	6551	321	247	1583
Massena	72	1802	6499	284	188	1377
NYC	75	1925	6603	332	242	1525
Poughkeepsie	73	2198	6563	286	201	1475
Syracuse	74	1854	6556	295	209	1497

Office

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	1334	1231	981	1286	1646	269
Binghamton	1315	1195	905	1156	1463	233
Buffalo	1299	1196	938	1154	1467	255
Massena	1382	1258	981	1315	1625	248
NYC	1183	1176	845	1258	1605	407
Poughkeepsie	1208	1165	742	1240	1606	344
Syracuse	1295	1213	1005	1236	1578	292

Hospital

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	2053	1665	1142	1645	1860	413
Binghamton	2053	1687	1142	1549	1681	380
Buffalo	2053	1678	1142	1591	1731	416
Massena	2053	1689	1142	1537	1588	395
NYC	2053	1713	1142	1801	2137	574
Poughkeepsie	2053	1718	1142	1694	1977	487
Syracuse	2053	1671	1142	1618	1796	415

Community College

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	606	683	497	429	452	216
Binghamton	716	682	496	510	534	256
Buffalo	663	631	460	471	495	237
Massena	553	835	383	390	412	197
NYC	419	399	290	293	312	150
Poughkeepsie	464	441	321	325	346	165
Syracuse	539	513	373	380	402	193

High School

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	350	232	60	513	674	203
Binghamton	359	234	58	509	661	169
Buffalo	358	233	53	511	660	176
Massena	357	238	65	518	663	187
NYC	327	231	44	531	707	241
Poughkeepsie	348	232	54	522	699	209
Syracuse	346	236	59	527	692	210

Large Retail

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	1049	3421	3287	1085	1282	280
Binghamton	1059	3481	3241	1074	1266	217
Buffalo	1062	3462	3270	1082	1272	240
Massena	1053	3448	3246	1080	1257	251
NYC	1020	3310	3411	1091	1310	396
Poughkeepsie	1036	3385	3361	1093	1306	341
Syracuse	1054	3429	3298	1089	1289	296

Dormitory

Climate	Measure Unit Savings (kWh/hp)			
	CW Pump	CHW Pump	HW Pump	Tower Fan
Albany	961	453	386	190
Binghamton	963	453	386	143
Buffalo	964	453	386	152
Massena	966	451	388	166
NYC	965	453	393	266
Poughkeepsie	962	450	387	244
Syracuse	966	452	388	204

University

Climate	Measure Unit Savings (kWh/hp)					
	CW Pump	CHW Pump	HW Pump	Return Fan	Supply Fan	Tower Fan
Albany	687	767	570	669	747	231
Binghamton	701	757	571	591	621	185
Buffalo	696	760	573	623	642	216
Massena	705	754	579	673	718	195
NYC	668	802	550	850	1038	308
Poughkeepsie	683	775	558	789	959	261
Syracuse	680	771	572	685	738	251

For the city, measure, and building type combinations not addressed above, use data supplied by National Grid shown below. The unit savings estimates are based on data developed by NSTAR for the Massachusetts TRM[72]. These values were trued up to National Grid evaluation studies by computing the ratio of the savings by VFD application from the National Grid Massachusetts Energy Initiative program evaluation to the average value by application across the NSTAR data.

[72] NSTAR VFD savings taken from Chan, T. *Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR*, June, 2010

This adjustment factor was then applied to each of the NSTAR values. The adjusted savings are shown below.

Measure Unit Savings (kWh/hp)

Building	Exh fan	CT fan	CHW pump	Boiler FW pump	HW pump	MAF	Return fan	Supply fan	WLHP circ pump
University/College	2,011			1,788		1,976			1,594
Elm/HSchool	1,968			1,492		2,088			1,334
Multi-Family	1,768			1,806		1,892	902	1,025	1,934
Hotel/Motel	1,740			1694		2,067			1,788
Health	1,863			1812		1,842			1,912
Warehouse	1,828	195	199	1,545	934	1,982	823	936	1,468
Restaurant	1,899	424	381	1,526	916	1,613	936	1,059	1,845
Retail	1,707			1,504		1,469			1,561
Grocery	1,726	392	398	1,275	752	1,368	924	1,007	1,711
Offices	1,840			1440		2,054			1,685

Peak demand savings were taken from the NSTAR data, as shown below:

Measure Unit Demand Savings (kW/hp)

Building	Exh fan	CT fan	CHW pump	Boiler FW pump	HW pump	MAF	Return fan	Supply fan	WLHP circ pump
University/College	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.061
Elm/HSchool	0.411	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.3
Multi-Family	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.061
Hotel/Motel	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.061
Health	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.061
Warehouse	0.119	-0.025	0.061	0.498	0.498	0.284	0.111	0.07	0.061
Restaurant	0.284	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.194
Retail	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.061
Grocery	0.284	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.194
Offices	0.119	-0.025	0.061	0.498	0.498	0.119	0.111	0.07	0.061

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APPENDIX L

MINIMUM MOTOR EFFICIENCY – EISA STANDARD

The Energy Independence and Security Act (EISA) of 2007 established NEMA Premium as the new standard for electric motor efficiency, effective December 2010. The energy savings baseline efficiency for all normal replacement motors rebated after the new standards take effect is shown below:

NEMA MG-1 Table 12-12 Full-Load Efficiencies for 60 Hz NEMA Premium® Efficient Electric Motors Rated 600 Volts or less (Random Wound)

Motor Horsepower	Nominal Full-Load Efficiency					
	Open Motors			Enclosed Motors		
	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole
1	77.0	85.5	82.5	77.0	85.5	82.5
1.5	84.0	86.5	86.5	84.0	86.5	87.5
2	85.5	86.5	87.5	85.5	86.5	88.5
3	85.5	89.5	88.5	86.5	89.5	89.5
5	86.5	89.5	89.5	88.5	89.5	89.5
7.5	88.5	91.0	90.2	89.5	91.7	91.0
10	89.5	91.7	91.7	90.2	91.7	91.0
15	90.2	93.0	91.7	91.0	92.4	91.7
20	91.0	93.0	92.4	91.0	93.0	91.7
25	91.7	93.6	93.0	91.7	93.6	93.0
30	91.7	94.1	93.6	91.7	93.6	93.0
40	92.4	94.1	94.1	92.4	94.1	94.1
50	93.0	94.5	94.1	93.0	94.5	94.1
60	93.6	95.0	94.5	93.6	95.0	94.5
75	93.6	95.0	94.5	93.6	95.4	94.5
100	93.6	95.4	95.0	94.1	95.4	95.0
125	94.1	95.4	95.0	95.0	95.4	95.0
150	94.1	95.8	95.4	95.0	95.8	95.8
200	95.0	95.8	95.4	95.4	96.2	95.8
250	95.0	95.8	95.4	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	95.8	96.2	96.2	95.8	96.2	95.8
500	95.8	96.2	96.2	95.8	96.2	95.8

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APPENDIX M

GUIDELINES FOR EARLY REPLACEMENT CONDITION

Getting Started

The full manual, beginning in Section 2, explains the concepts of the tables and their use, and the choices offered to PAs. It also contains various instructions on such matters as data retention and the tracking database. This first section contains the immediate directions to get a quick start on the simplest case. These tables can only be used regarding the proposed replacement of equipment that has not reached its prescribed Effective Useful Life (EUL). Two other conditions are pertinent to use of this page:

The PA accepts agrees to use the assumptions for each measure regarding the typical relationship between incremental costs and savings and the full costs and savings of replacing the older (but pre-EUL) equipment with the high efficiency equipment promoted by the program. The measures in question are listed in Table M-1 *without* an "a" or a "b" superscript.

If these conditions are met, the fundamental steps for calculation would be as follows:

- Calculate the full costs of replacing the old equipment with the program measure, including labor.
- Calculate the full first year savings of the program measure using the existing equipment as the baseline, assume such savings through the EUL of the new equipment, monetize the savings per the prescribed annual Long Run Avoided Costs (LRACs) estimates, and calculate the present value of this stream of monetized savings using Staff‟s discount rate. This present value is referred to herein as the Inflated Benefits.[73]
- Estimate the remaining useful life (RUL) of the old equipment in place.
- Turn to the measure-specific costs and savings tables of the measure in question (the measures are grouped by the EUL on Table M-1).
- Go down each table to the row for the estimated RUL and find the percentage adjustment factor in the column for the measure.
- Multiply the Inflated Benefits by the benefits factor.
- Multiply the full costs by the costs factor.
- For Total Resources Cost (TRC) analysis, use the two products from steps 6 and 7.
- For first year savings to report against approved program goals, use the full savings.

Introduction

In the EEPS Order issued on October 18, 2010 (p.9),[74] the Commission stated, regarding TRC analysis of early replacements in individual projects, that it was ". . . directing Staff to develop a

[73] "Inflated Benefits" is simply a concept designed to be an intermediate step in the computation of estimated dual baseline benefits, using the tables in this Appendix. It does not imply an assumption that the old equipment, absent the program, would have continued in use through the life of the new equipment.

[74] Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Consolidation and Revision of Technical Manuals (issued October 18, 2010).

new approach, based on the dual baseline approach, which provides consistency between the treatment of savings and costs. The Director of the Office of Energy Efficiency and Environment is directed to compile and provide simplifying lookup tables, which provide early replacement method energy savings consistent with the dual baseline concept as an attachment to the consolidated Technical Manual (TM)." Staff was also directed "to develop a consistent cost estimation approach which reflects the concept that the costs of making a high efficiency early replacement will avoid an end-of useful-life replacement with minimally code compliant equipment."

Early Replacement vs. Normal Replacement

Early replacement is defined in the Order as the replacement of equipment before it reaches its Effective Useful Life (EUL), whereas end-of-life or normal replacement refers to the replacement of equipment that has reached or passed the end of its measure-prescribed EUL. The crucial difference between end-of-life replacement and early replacement is that end-of-life/normal uses "incremental" costs and savings while early replacement uses "full" values:

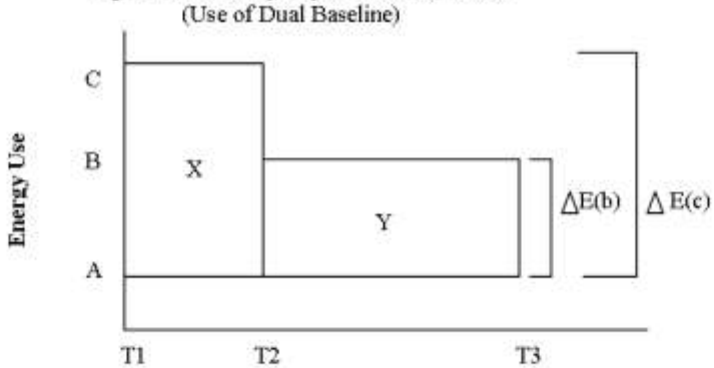
- *Incremental savings* is defined as the annual energy use of the currently-on-the-market standard, minimally compliant equipment minus the annual energy use of the high efficiency equipment subsidized by the program.
- *Full savings* is defined as the annual energy use of the old equipment in place minus the annual energy use of the high efficiency equipment subsidized by the program.
- *Incremental cost* is defined as the full cost of new efficient equipment minus the cost of the currently-on-the-market standard, minimally-compliant equipment, plus the time value penalty (the present value cost of a dollar amount increases with earlier spending, see below).
- *Full cost* is simply the cost (including installation) of the new efficient equipment.

Early replacement not only accelerates savings to the electric grid but also allows PAs to claim greater first-year annual savings toward their annual energy goals because full savings are reported as the first-year savings. *If a PA cannot substantiate that the age of the equipment in place is less than its EUL and therefore a case of early replacement,* the replacement must be screened as normal (end of life) replacement, with the incremental savings reported as the first-year savings toward approved program goals.

In both normal and early replacement conditions, the establishment of the correct baseline is critical in accurately estimating gross energy and demand impacts. However, while the TM addresses the establishment of the baseline for normal replacement conditions, it rarely addresses the establishment of baselines for early replacement conditions. This Appendix M provides two sets of lookup tables and guidance designed to simplify the complex mathematical analysis of dual-baseline cases and reduce PA data needs. The first set of tables, for *typical* early replacement measure conditions as developed by TecMarket Works, reflects data, discussed below, that PAs might find it difficult to obtain. The second set of tables requires PAs to provide these data but still simplifies the calculations.

The standard early replacement condition, illustrated in Figure 1, involves a customer who replaces equipment before it reaches the end of its EUL. That is, the equipment is fully functioning and would continue to function for some period of time; referred to as the remaining useful life (RUL). However, the customer is induced by the program to replace this existing equipment with more efficient equipment. It is assumed that at the end of the RUL, absent the program, the customer would have installed equipment that would meet the existing efficiency code or appliance standard, i.e., equipment that represents the market average efficiency or the efficiency that had become the industry standard (referred to as the *code/standard equipment*).

Figure 1. The Early Replacement Condition (Use of Dual Baseline)



C = Energy use of pre-existing measure
B = Energy use of code/standard measure
A = Energy use of new efficient measure
T1 = Date on which new efficient measure is installed
T2 = Date on which existing measure was expected to have failed
T3 = Date on which the new efficient measure is expected to fail
T3—T1= Expected effective useful life (EUL) of the new efficient measure
T2—T1= Expected remaining useful life (RUL) of the pre-existing measure
T3 - T2 = Expected remaining EUL of the new efficient measure
Δ E(c) = The full savings defined as C - A
Δ E(b) = The incremental savings defined as B - A

Energy savings in this example would consist of two portions. The customer would have experienced the full savings defined by Area **X** (energy use C-A for the RUL period T2-T1). At the end of the RUL, the savings for the period T3-T2 would be reduced to incremental savings defined by area **Y**. To carry out these calculations, information on two (dual) baselines is required, the energy use of the pre-existing equipment and the energy use of code/standard equipment. Information on energy use for the high efficiency equipment provided through the program will also be required.

The cost would also have to be calculated in a manner consistent with early replacement. In normal replacement situations, one would use the incremental cost that is defined as the cost of the new efficient equipment minus the cost of the code/standard equipment. In the early replacement case, the incremental cost is calculated in a slightly different manner. This calculation recognizes that, while the customer purchased efficient equipment with the assistance of the program, it would have purchased code/standard equipment at some time in the future, i.e., at the end of the RUL, had the program not existed.

Thus, one would first have to determine the full cost of the new efficient equipment (including the installation labor) at T1 *and* the full cost of the code/standard equipment (including the installation labor) at T2. The incremental costs would then be calculated as the cost of the new efficient equipment minus the present value (PV) of the cost that is avoided in the future for the code/standard equipment. Figure 2 presents a case in which the RUL is 4 years and, absent the program, the code/standard equipment would have been installed in the fifth year. This calculation differs from the normal/end of life replacement incremental cost in adding the time value of money for spending earlier.

Figure 1. Incremental Cost Calculation for an Early Replacement of Equipment with an RUL of Four Years

Year	PV with Program	PV without Program
1	Full cost of high efficient equipment	0
2	0	0
3	0	0
4	0	0
5	0	Full cost of Code/Standard Equipment

The two key inputs necessary for these calculations, the energy use and the cost of the code/standard equipment, may not be readily available to PA field staff and are subject to change before the end of the equipment‟s RUL in the absence of a program. Note that the first set of tables in this Appendix M is based on current codes and standards. If a PA can document the needed energy use and cost data, it can choose to use the second set of tables. Both sets of tables are based on a "ratio approach".

The Ratio Approach to the Dual Baseline with the Lookup Tables

This approach focuses on the ratio of incremental savings to full savings[75] and the ratio of incremental costs to full costs. These ratios, shown at the top of the attached tables, determine the factors that PAs can use to adjust the savings and cost data they do have. The first set of tables, the measure-specific set, allows the early replacement calculations to be performed in a manner that only requires the program administrator to have the Remaining Useful Life (RUL) of the equipment in place and the full savings and costs of the project. The ratios in the first set of tables (M-2 through M-19) were developed by TecMarket Works. The second set of tables (M-29 through M-38), the non-measure-specific set, requires the program administrators to provide their own incremental costs and savings ratios (based on the code/standard equipment). To use the second set of tables, PAs must match ratios that they have calculated to corresponding ratios in the tables.

The source of these two ratios for the first set of tables is the Database for Energy Efficient Resources (DEER), most recently updated by Itron for the California Public Utility Commission in 2009. Among other things, DEER contains energy use and costs for selected energy-efficient technologies and equipment in the residential and nonresidential sectors. DEER also contains the same information for typical equipment, those commonly installed in the marketplace.

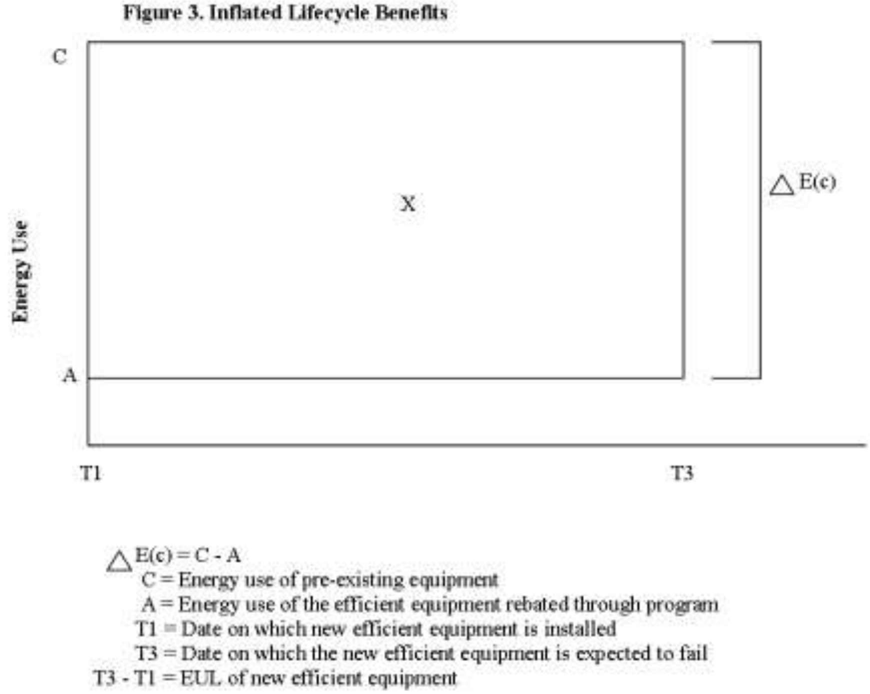
[75] The savings values ratios are not lifecycle present values but are rather the line segments in Figure 1 on the vertical axis: (B – A) divided by (C – A).

To use either set of tables PAs will need to calculate the first-year annual savings as the annual energy use of the old equipment in place minus the annual energy use of the high efficiency equipment (the full savings). These full savings are then counted for each year of the EUL as is represented as area *X* in Figure 3. For each year of the EUL (T3 – T1) of the new equipment, the full kWh or therm savings are converted to dollar benefits by multiplying them by the Commission‟s avoided costs estimates for that year. As a preliminary step in using the tables, the PAs will calculate this "inflated lifecycle benefits" as the present value of the stream of full savings benefits for the EUL of the new equipment.

In cases of early replacement under the ratio approach, it is these inflated lifecycle benefits that must be adjusted using the appropriate *inflated lifecycle benefits adjustment factor*. For a given measure with a given EUL, RUL and ratio of incremental savings to full savings, the inflated lifecycle benefits adjustment factor is the ratio (presented as a percentage) of the present value of the dual baseline lifecycle benefits (X+Y) illustrated in Figure 1 to the present value of the inflated lifecycle benefits illustrated in Figure 3.

PAs can obtain these factors from either the set of DEER-based tables or from the set of PA-based tables if a PA can calculate its own incremental savings to full savings ratios.

Figure 3. Inflated Lifecycle Benefits



Under the Commission requirement of consistent treatment of savings and costs, the full costs[76] must also be adjusted downward. PAs can obtain the *full cost adjustment factors* from either the DEER-based Tables based on typical ratios of incremental cost to full cost or from the PA-based Tables if a PA can calculate its own incremental cost to full cost ratios. The DEER-based set of lookup tables runs from M-2 through M-28. Of these, M-2 through M-10 cover benefits, M-11 through M-19 costs, and M-20 through M-28 adjusted EULs. The PA-based set of lookup tables runs from M-29 through M-47. Of these, M-29 through M-37 cover benefits, M-38 all costs (only the RUL matters, not the EUL), and M-39 through M-47adjusted EULs.

DEER-Based Look-Up Tables

The first set of tables includes look-up tables M-2 through M-10, which present the *Inflated Lifecycle Benefit Adjustment Factors*. The tables are based primarily on data contained in the California 2009 DEER. For each qualified equipment type, the median ratio of incremental savings to the full savings was calculated. These ratios along with the RULs, ranging from 1 year to the EUL minus 1 year, are shown in the look-up tables and are used to derive the factors needed to adjust the inflated lifecycle benefits.

Tables M-11 through M-19 present the *full cost adjustment factors,* for the same equipment addressed in Tables M-2 through M-10, for the same RUL ranges. For each qualified equipment type, the median ratio of incremental costs to the full costs was calculated.

To use these tables of typical ratios, a PA must have gathered the following four pieces of information:

- the EUL of the new efficient equipment,
- the RUL of the old equipment in place,
- the full savings of the equipment (annual energy use of the old equipment in place minus the annual energy of the high efficiency equipment supported by the program), and
- the full costs (including installation)

The EUL for a given measure is obtained from Table M-1, which is a compilation of the EULs for all the relevant measures in the consolidated Technical Manual effective January 1, 2011 that could qualify for early replacement[77]. The RUL[78], the full savings, and the full costs are provided by the program implementer. Note that documentation for PA estimates of these data must be retained for possible Staff review. Table M-1 also presents the normal replacement baseline equipment against which each of the 29 measures covered in this table is compared. Note that the lookup tables apply only to the 23 measures without an ***a*** or ***b*** designation in Table M-1.

[76] Full costs include the capital cost of the new efficient equipment plus installation cost.

[77] Early replacement is inappropriate for such equipment as wall insulation, right sizing, setback thermostats, and sub-metering since nothing is being replaced. Lighting equipment has also been excluded since it is expected to be treated as pre-qualified.

[78] Upon request, Staff will provide a suggested questionnaire to assist in the determination of the RUL.

Table M-1. Early Replacement Measures, EULs, and Baselines

Measures	EUL	Normal Replacement Baseline
Heat Pump Water Heater: Residential	10	Code Electric Storage Water Heater
Room Air Conditioner: Residential	10	EPACT Room Air Conditioner
Clothes Washer: Single Family: Residential	11	EPACT Clothes Washer
ENERGY STAR Dishwashers: Residential	11	EPACT Dishwasher
Water Heater: Gas: Residential	11	Code Gas Storage Water Heater
Energy Star Dehumidifier: Residential[a]	12	Standard Efficiency Dehumidifier
Refrigerators: Nonresidential	12	EPACT Refrigerator
Indirect Water Heaters: Residential	13	Code Gas Storage Water Heater
Water Heater: Electric: Residential	13	Code Electric Storage Water Heater
Clothes Washer: Multi-Family Residential	14	EPACT Clothes Washer
Air Compressor Upgrade: Nonresidential	15	Standard Efficiency Rotary Screw Compressor
Central Air Conditioning: Residential	15	Code Central AC with gas heat
Central Air Source Heat Pumps: Residential	15	Code Central Air Source Heat Pump
Cool Roof: Nonresidential[a]	15	Standard Roof
Cooling Tower: Nonresidential[a]	15	Standard Efficiency Cooling Tower
Efficient Air-Cooled Refrigeration Condenser: Nonresidential[a]	15	Standard Efficiency Refrigeration Condenser
Indirect Water Heaters: Nonresidential	15	Code Gas Storage Water Heater
Motors: Nonresidential[b]	15	EISA Minimum Efficiency Motor
Packaged Air Conditioners (Central AC): Nonresidential	15	Code Packaged Air Conditioner
Packaged Air Source Heat Pumps (CAC Cooling Only): Nonresidenti	15	Code Packaged Air Source Heat Pump
Water Heaters: Nonresidential (Gas & Electric)	15	Code Storage Water Heater
Refrigerators: Residential	17	EPACT Refrigerator
Chillers: Nonresidential	20	Code Chiller
Gas Furnaces and Boilers: Nonresidential	20	Code Furnace and Boiler
High Efficiency Gas Furnaces: Residential	20	Code Furnace
High Performance Glazing: Nonresidential[b]	20	Code Glazing
High Performance Windows (Gas Heating Only): Residential	20	Code Window
Instantaneous Water Heater: Residential	20	Code Storage Water Heater
Gas Boilers: Residential	25	Code Boiler

EPACT refers to efficiency standards promulgated by the Energy Policy and Conservation Act of 2005

EISA refers to efficiency standards promulgated by the Energy Independence and Security Act of 2007

Code refers to New York State Construction codes, which reference ASHRAE standards.

For measures assigned an **a**, the efficiency of the old in place unit is still the common practice or no new standards have been adopted, i.e., the baseline for the full savings and the incremental savings are the same. As a result, the ratio of incremental to full savings is near 1.0, meaning that a PA can claim the full savings for the entire EUL of the new equipment (areas X and Y in Figure 4). Therefore, the lookup tables do not apply.

For these measures assigned a **b**, the high efficiency equipment subsidized by the program is consistent with current code or standards. For these measures, the incremental savings are zero and thus the ratio of incremental to full savings is 0.0.This means that a PA can claim full savings for only the RUL (area X in Figure 5), after which the high-efficiency replacement would have occurred anyway. Therefore, the lookup tables do not apply.

Figure 4. Efficiency of the Old In Place Unit Is Still the Common Practice Or No New Standards

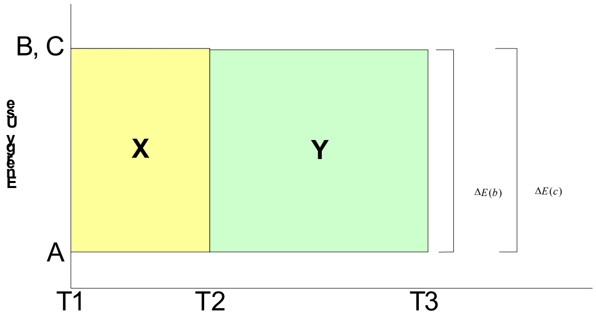
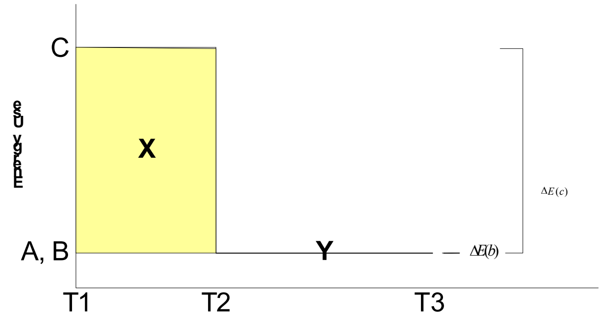


Figure 5. High Efficiency Equipment Subsidized by the Program Is Consistent with Current Code Or Standards



$\Delta E(c)$ = C - A

$\Delta E(b)$ = B - A

C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3= Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected remaining useful life (RUL) of the pre-existing equipment
T3 – T2 = Expected remaining EUL of the new efficient equipment

After obtaining the four pieces of information listed above, the program implementer can determine the appropriate inflated lifecycle benefits adjustment factor by which to multiply the inflated lifecycle benefits and the full cost adjustment factor by which to multiply the full costs. These adjusted inflated lifecycle benefits and adjusted full costs are to be used in the TRC ratio in the screening of measures in specific projects.

4.1.1 Table Organization

The DEER-Based Tables are divided into two groups:

- Inflated Lifecycle Benefit Adjustment Factors (Tables M-2 through M-10)
- Full-Cost Adjustment Factor (Tables M-11 through M-19)

Each set of tables addresses the same 23 measures or varieties of measures grouped by the EUL.

In each table, the left *column* contains the RULs from 1 year through the EUL minus 1 year. For example, Table M-5 presents Inflated Lifecycle Benefit Adjustment Factors for measures with an EUL of 15 years. Therefore, Table M-5 contains RULs from 1 through 14.

- The *first row* of each table contains the names of each measure addressed in the table.
- The *second row* of each table indicates whether the measure is residential, non-residential or both.
- The *third row* of each table lists the median ratio associated with each measure. For Tables M-2 through M-10 and Tables M-20 through M-28, the ratio is the ratio of the incremental savings to the full savings for each measure. For Tables M-11 through M-19, the ratio is the ratio of the incremental costs to the full costs for each measure.

The remaining *cells* in the matrix contain:

- For Tables M-2 through M-10, the cells contain the Inflated Lifecycle Benefit Adjustment Factors
- For Tables M-11 through M-19, the cells contain the Full-Cost Adjustment Factors

4.1.2 Example

Consider the following example for a group of five measures, residential and non-residential air conditioners (central ACs/packaged units) covering four levels of efficiency, each with an EUL of 15 years:

- non-residential domestic electric water heaters (service hot water),
- non-residential domestic gas water heaters,
- non-residential indirect water heaters, and
- non-residential air compressors.

Table M-5 presents the inflated lifecycle benefits adjustment factors for these five measures. For central air conditioners, the program implementer must determine the SEER of the new efficient unit, estimate the RUL for the old unit in place, and select the appropriate lifecycle benefits adjustment factor. For example, if the SEER of the new efficient unit is 17 and the estimated RUL is 4 years, Table M-5 shows that the *inflated lifecycle benefits adjustment factor* is 0.63. Thus, the inflated lifecycle benefits should be multiplied by 0.63.

For a central air conditioner with a SEER of 17 and an estimated RUL of 4 years, Table M-14 shows that the *full-cost adjustment factor* is 0.44. Thus, the full cost of the new efficient central air conditioner should be multiplied by the full-cost adjustment factor of 0.44.

4.1.3 Trends on the Lookup Tables and Calculation of Ratios

This section discusses the directions in which RULs and the savings and costs ratios affect the adjustment factors, and illustrates how the ratios are calculated.

- *Tables M-2 through M-10*: The longer the RUL is, the larger the share of the inflated lifecycle benefits that a PA can claim. Also, the greater the ratio of incremental savings to full savings; the larger the share of the inflated lifecycle benefits that a PA can claim. Consider the following example of equipment with an EUL of 10 years and annual kWh use of 2,000 kWh that is removed in its 6^{th} year (RUL=4 years) and replaced with an energy efficient version of the equipment with an annual kWh use of 1,400 kWh. The full savings are 600 kWh (2,000 - 1,400). It is assumed that in four years the customer would have installed equipment that, at a minimum, met the current efficiency code of annual energy use. The ratio will change depending on the efficiency of the code/standard equipment:

    - If the kWh use associated with code/standard is 1,600 kWh, then the incremental savings = (1,600 – 1,400) or 200 and the ratio = (200/600) or 0.33.

    - If the kWh use associated with code/standard is 1800 kWh, then the incremental savings = (1,800 – 1,400) or 400 and the ratio = (400/600) or 0.67.

A less strict code (one that allows higher consumption) allows a PA to claim a larger share of the inflated lifecycle benefits. In other words, the higher the kWh use associated with the code/standard equipment, the more the program is accomplishing in avoiding standard equipment.

- *Tables M-11 through M-19*: The longer the RUL is, the larger the share of the unadjusted costs for a PA to include (larger time value penalty). Also, the greater the ratio of incremental costs to full costs is, the larger the share of the unadjusted costs for a PA to include. Continuing with the above example, assume that the full cost of the energy efficient equipment is $2,000. It is assumed that in four years the customer would have installed code/standard equipment. The ratio will change depending on the cost of the code/standard equipment:

    - If the full cost of the minimally compliant equipment is $1,400, then the incremental cost = $600 and the ratio = ($600/$2,000) or 0.30.

    - If the full cost of the minimally compliant equipment is $1,800, then the incremental cost = $200 and the ratio = ($200/$2,000) or 0.10.

- The higher cost of the minimally compliant equipment, which lowers the incremental cost, allows a PA to take into account a smaller portion of the full cost of the efficient measure when calculating a TRC. In other words, the higher the cost of the minimally compliant equipment that the customer would have incurred without the program, the lower the cost of the program.

4.2. PA-Based Look-Up Tables

If a PA is able to calculate its own ratio of the incremental savings to full savings and/or the ratio of incremental costs to full cost, then they may choose to use the second set of tables. If a PA chooses to use its own savings ratio and/or cost ratio, it should identify the ratio in the appropriate tables (M-29 through M-47) that is closest to the one(s) it developed. These 19 tables are for the most part organized and interpreted in the same manner as Tables M-2 through M-28. The only exceptions are that the ratios range[79] from 0.95 to .05 in increments of 0.05, and there are no measure designations. To use these tables, a PA will still need to gather the same four pieces of information needed to use the first set of tables:

- the EUL of the new efficient equipment,
- the RUL of the old equipment in place,
- the full savings of the equipment (annual energy use of the old equipment in place minus the annual energy of the high efficiency equipment supported by the program), and
- the full costs (including installation)

Additionally, the PA will need documented estimates of incremental costs and savings in order to calculate:

- The ratio of incremental savings to full savings, and/or

[79] The lookup tables do not apply to measures that have a ratio of *incremental savings to full savings* or a ratio of *incremental costs to full costs* of 1.0 or 0.0 for the same reasons provided earlier in Section 2.1.

- The ratio of incremental costs to full cost

Note that all documentation for PA estimates of this data must be retained for Staff review, in accordance with Guidance Document EE-08, dated March 31, 2014. This guidance document can be found at:
www3.dps.ny.gov/W/PSCWeb.nsf/All/31D14D1DDC55FB2185257B240062B398?OpenDocument

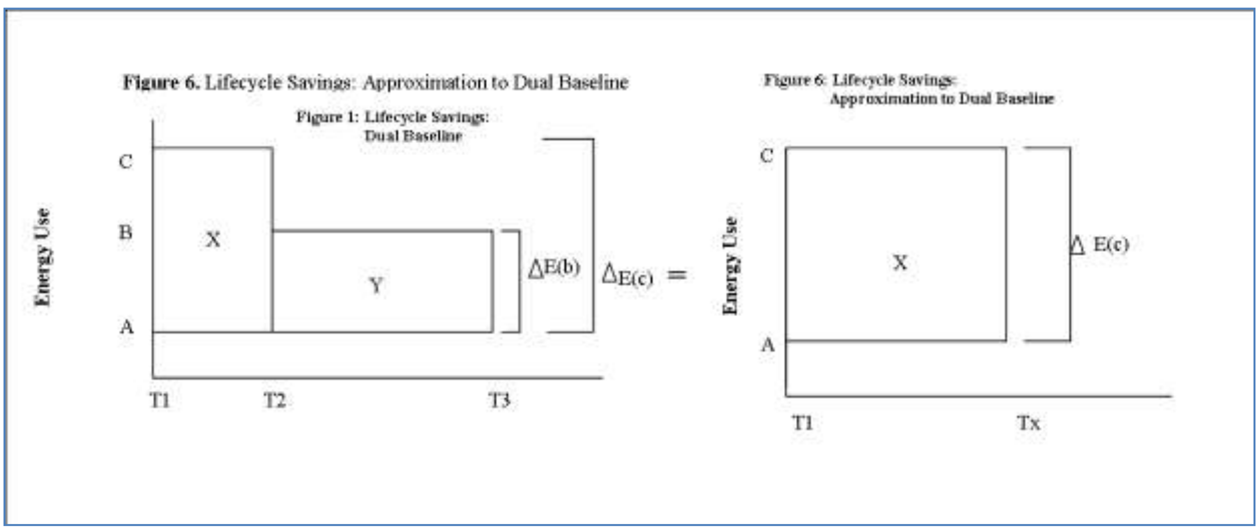
Program-Tracking Database Requirements

The program tracking databases are maintained by the PAs for the purposes of current reporting and future impact evaluations. The Impact Evaluation section has many fields not used for current reporting. The Department of Public Service hereby adds, for cases of early replacement, six additional required variables.

Type of Installation (TRC Approach)[80] ,

- The *Adjusted Full Savings* (full savings multiplied by the full-savings adjustment factor),
- The *Adjusted Full Cost* (full cost multiplied by the full-cost adjustment factor),
- The Ratio of Incremental Savings to Full Savings,
- The Ratio of Incremental Costs to Full Costs, and
- The *Adjusted EUL* (discussed below)

The Adjusted EUL is defined as that period of years over which the full savings would be claimed such that it matches the present value dollar benefits of the underlying dual baseline. That is, the EUL of the new equipment in Figure 6 below, represented by **Tx – T1**, is adjusted so that the present value of lifecycle benefits represented by area **X** in Figure 6 is equivalent to the present value of the lifecycle benefits represented by the sum of areas **X** and **Y** in Figure 1.



80 ER=Early Replacement; NR=Normal Replacement; SC=Special Circumstance; AO=Add On. Add on refers to adding something, which replaces nothing. Examples include adding controls to a boiler that had none, or adding insulation where there was none or some. Add-on measures are modeled at full costs and full savings for the length of their EULs. The full savings are reported toward first-year goals.

The longer the RUL is, the larger the adjusted EUL. This follows the same logic as the case of the *inflated lifecycle benefit adjustment factors* except that the result is an adjusted EUL (that portion of the EUL for which the PV of using the full savings would equal the PV of the dual baseline savings).

PAs can obtain the adjusted EULs from the DEER-Based Tables based on typical ratios of incremental savings to full savings or from the PA-Based Tables if a PA can calculate its own savings ratios. The adjusted EUL is not used for TRC screening, but for the program"s tracking database. The tables are organized in the same way as the earlier tables. The only difference is that the cells in the matrix contain adjusted EULs in years. Tables M-20 through M-28 contain DEER-Based adjusted EULs while Tables M-39 through M-47 contain PA-Based adjusted EULs.

Table M-2. Inflated Lifecycle Benefit Adjustment Factors: Residential Boilers

	Boiler-G
	Res
	Median Ratio of Incremental Savings to Full Savings
	0.15
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	20%
2	26%
3	32%
4	37%
5	42%
6	47%
7	52%
8	56%
9	60%
10	64%
11	68%
12	68%
13	71%
14	75%
15	78%
16	81%
17	84%
18	86%
19	89%
20	91%
21	94%
22	94%
23	96%
24	98%
EUL =	25

Table M-3. Inflated Lifecycle Benefit Adjustment Factors: Chillers, Furnaces, Non-Res Boilers, and High Performance Windows

	Chiller: Air Cooled Recip and Screw	Chiller: Water Cooled Recip	Chiller: Water Cooled Screw < 150 ton	Chiller: Water Cooled Screw 150-300 ton	Chiller: Water Cooled Screw > 300 ton	Chiller: Water Cooled Centrifugal < 150 ton	Chiller: Water Cooled Centrifugal 150-300 ton	Chiller: Water Cooled Centrifugal > 300 ton	Boiler-G	Furnace-G (AFUE 90)	Furnace-G (AFUE 92)	Furnace-G (AFUE 94)	Furnace-G (AFUE 96)	High Performance Windows-G
	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res
	Median Ratio of Incremental Savings to Full Savings													
	0.50	0.15	0.37	0.31	0.69	0.58	0.38	0.31	0.27	0.44	0.48	0.51	0.54	0.63
RUL	Artificial Lifecycle Benefit Adjustment Factors													
1	53%	23%	42%	36%	72%	63%	42%	36%	35%	47%	53%	53%	58%	68%
2	58%	29%	47%	42%	72%	63%	47%	42%	35%	53%	58%	58%	63%	68%
3	63%	36%	53%	47%	76%	67%	53%	47%	41%	58%	58%	63%	63%	72%
4	63%	42%	58%	53%	76%	72%	58%	53%	47%	63%	63%	68%	68%	72%
5	67%	47%	58%	58%	80%	72%	58%	58%	53%	63%	68%	68%	72%	76%
6	72%	53%	63%	58%	80%	76%	63%	58%	58%	68%	68%	72%	72%	80%
7	72%	53%	67%	63%	84%	76%	67%	63%	63%	72%	72%	76%	76%	80%
8	76%	58%	72%	67%	84%	80%	72%	67%	68%	72%	76%	76%	80%	84%
9	80%	63%	72%	72%	87%	84%	72%	72%	68%	76%	76%	80%	80%	84%
10	80%	67%	76%	76%	87%	84%	76%	76%	72%	80%	80%	80%	84%	87%
11	84%	72%	80%	76%	91%	87%	80%	76%	76%	80%	84%	84%	84%	87%
12	87%	76%	84%	80%	91%	87%	84%	80%	80%	84%	84%	87%	87%	91%
13	87%	80%	84%	84%	94%	91%	84%	84%	84%	87%	87%	87%	87%	91%
14	91%	84%	87%	87%	94%	91%	87%	87%	84%	87%	91%	91%	91%	94%
15	91%	87%	91%	87%	94%	94%	91%	87%	87%	91%	91%	91%	94%	94%
16	94%	91%	91%	91%	97%	94%	91%	91%	91%	94%	94%	94%	94%	94%
17	94%	91%	94%	94%	97%	97%	94%	94%	94%	94%	94%	94%	97%	97%
18	97%	94%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%
19	100%	97%	97%	97%	100%	100%	97%	97%	97%	97%	97%	100%	100%	100%
EUL =	20													

Table M-4. Inflated Lifecycle Benefit Adjustment Factors: Residential Refrigerators

	Refrigerator-E
	Res
	Median Ratio of Incremental Savings to Full Savings
	0.11
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	17%
2	25%
3	32%
4	39%
5	46%
6	52%
7	58%
8	64%
9	69%
10	74%
11	79%
12	79%
13	84%
14	88%
15	92%
16	96%
EUL =	17

Table M-5. Inflated Lifecycle Benefit Adjustment Factors: Central Air Conditioners, Air Source Heat Pumps, Non-Res Water Heaters, Indirect Water Heaters, and Air Compressor Upgrades

	Central Air conditioner (SEER 14)	Central Air conditioner (SEER 15)	Central Air conditioner (SEER 16)	Central Air conditioner (SEER 17)	Central Air conditioner (SEER 18)	DHW-E	DHW-G	Indirect Water Heater-G	Air Compressor Upgrade-E
	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Non-Res	Non-Res	Non-Res	Non-Res
	Median Ratio of Incremental Savings to Full Savings								
	0.19	0.31	0.38	0.44	0.48	0.60	0.21	0.34	0.48
RUL	Artificial Lifecycle Benefit Adjustment Factors								
1	27%	35%	50%	50%	56%	63%	35%	42%	50%
2	35%	43%	50%	56%	56%	69%	35%	49%	56%
3	43%	50%	56%	56%	63%	69%	42%	49%	63%
4	50%	56%	56%	63%	69%	75%	49%	56%	69%
5	56%	63%	63%	69%	69%	75%	56%	63%	69%
6	56%	63%	69%	69%	75%	80%	63%	69%	75%
7	63%	69%	75%	75%	75%	80%	63%	69%	75%
8	69%	75%	75%	80%	80%	86%	69%	75%	80%
9	75%	80%	80%	80%	86%	86%	75%	80%	86%
10	80%	80%	86%	86%	86%	91%	80%	86%	86%
11	86%	86%	86%	91%	91%	91%	86%	86%	91%
12	91%	91%	91%	91%	91%	95%	91%	91%	91%
13	91%	95%	95%	95%	95%	95%	91%	96%	95%
14	95%	95%	95%	95%	95%	100%	96%	96%	95%
EUL =	15								

Table M-6. Inflated Lifecycle Benefit Adjustment Factors: Multi-Family Clothes Washers

	Clothes Washer-G
	MF Res
	Median Ratio of Incremental Savings to Full Savings
	0.39
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	45%
2	52%
3	59%
4	59%
5	66%
6	72%
7	72%
8	78%
9	84%
10	84%
11	90%
12	95%
13	95%
EUL =	14

Table M-7. Inflated Lifecycle Benefit Adjustment Factors: Residential Electric and Indirect Water Heaters

	DHW-E	Indirect Water Heater-G
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.60	0.34
RUL	Artificial Lifecycle Benefit Adjustment Factors	
1	69%	46%
2	69%	46%
3	69%	54%
4	76%	62%
5	76%	62%
6	83%	69%
7	83%	76%
8	89%	82%
9	89%	82%
10	94%	89%
11	94%	94%
12	100%	94%
EUL =	13	

Table M-8. Inflated Lifecycle Benefit Adjustment Factors: Non-Res Refrigerators

	Refrigerator-E
	Non-Res
	Median Ratio of Incremental Savings to Full Savings
	0.34
RUL	Artificial Lifecycle Benefit Adjustment Factors
1	41%
2	50%
3	58%
4	58%
5	66%
6	73%
7	81%
8	81%
9	87%
10	94%
11	94%
EUL =	12

Table M-9. Inflated Lifecycle Benefit Adjustment Factors: Clothes Washers, Dishwashers, and Residential Gas Water Heaters

	Clothes Washer-E	Dishwasher-E	DHW-G
	Res	Res	Res
	Median Ratio of Incremental Savings to Full Savings		
	0.39	0.33	0.21
RUL	Artificial Lifecycle Benefit Adjustment Factors		
1	43%	43%	33%
2	53%	53%	43%
3	62%	53%	43%
4	62%	62%	52%
5	70%	70%	61%
6	78%	78%	70%
7	78%	78%	78%
8	86%	86%	86%
9	93%	93%	86%
10	93%	93%	93%
EUL =	11		

Table M-10. Inflated Lifecycle Benefit Adjustment Factors: Heat Pump Water Heaters and Room A/C

	Heat Pump Water Heater-E	Room Air Conditioner-E
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.87	0.25
RUL	Artificial Lifecycle Benefit Adjustment Factors	
1	92%	36%
2	92%	47%
3	92%	57%
4	92%	57%
5	92%	66%
6	92%	75%
7	100%	84%
8	100%	84%
9	100%	92%
EUL =	10	

Table M-11. Full-Cost Adjustment Factors: Residential Boilers

	Boiler-G
	Res
	Median Ratio of Incremental Cost to Full Cost
	0.16
RUL	Full Cost Adjustment Factors
1	20%
2	25%
3	28%
4	32%
5	36%
6	39%
7	42%
8	45%
9	48%
10	51%
11	53%
12	56%
13	58%
14	60%
15	62%
16	64%
17	66%
18	68%
19	70%
20	71%
21	73%
22	74%
23	75%
24	77%
EUL =	25

Table M-12. Full-Cost Adjustment Factors: Chillers, Furnaces, Non-Res Boilers, and High Performance Windows

	Chiller: Air Cooled Recip and Screw	Chiller: Water Cooled Recip	Chiller: Water Cooled Screw < 150 ton	Chiller: Water Cooled Screw 150-300 ton	Chiller: Water Cooled Screw > 300 ton	Chiller: Water Cooled Centrifugal < 150 ton	Chiller: Water Cooled Centrifugal 150-300 ton	Chiller: Water Cooled Centrifugal > 300 ton	Boiler-G	Furnace-G (AFUE 90)	Furnace-G (AFUE 92)	Furnace-G (AFUE 94)	Furnace-G (AFUE 96)	High Performance Windows-G
	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res
	Median Ratio of Incremental Cost to Full Cost													
	0.18	0.03	0.16	0.13	0.12	0.21	0.24	0.33	0.48	0.28	0.31	0.34	0.36	0.10
RUL	Full Cost Adjustment Factors													
1	22%	8%	20%	18%	17%	25%	28%	36%	51%	32%	35%	37%	39%	15%
2	26%	13%	25%	22%	21%	29%	32%	40%	53%	35%	38%	41%	42%	19%
3	30%	17%	28%	26%	25%	33%	35%	43%	56%	39%	41%	44%	45%	23%
4	34%	22%	32%	30%	29%	36%	39%	46%	58%	42%	44%	47%	48%	27%
5	37%	26%	36%	33%	33%	40%	42%	49%	60%	45%	47%	50%	51%	31%
6	41%	30%	39%	37%	36%	43%	45%	51%	62%	48%	50%	52%	54%	35%
7	44%	33%	42%	40%	40%	46%	48%	54%	64%	51%	53%	55%	56%	38%
8	47%	37%	45%	43%	43%	49%	50%	56%	66%	53%	55%	57%	58%	41%
9	49%	40%	48%	46%	46%	51%	53%	59%	68%	56%	57%	59%	60%	44%
10	52%	43%	51%	49%	48%	54%	56%	61%	70%	58%	60%	61%	63%	47%
11	54%	46%	53%	52%	51%	56%	58%	63%	71%	60%	62%	63%	64%	50%
12	57%	49%	56%	54%	54%	58%	60%	65%	73%	62%	64%	65%	66%	53%
13	59%	52%	58%	57%	56%	61%	62%	67%	74%	64%	66%	67%	68%	55%
14	61%	54%	60%	59%	58%	63%	64%	68%	75%	66%	67%	69%	70%	57%
15	63%	57%	62%	61%	61%	65%	66%	70%	77%	68%	69%	70%	71%	60%
16	65%	59%	64%	63%	63%	66%	68%	72%	78%	69%	71%	72%	73%	62%
17	67%	61%	66%	65%	65%	68%	69%	73%	79%	71%	72%	73%	74%	64%
18	69%	63%	68%	67%	66%	70%	71%	74%	80%	73%	74%	75%	76%	66%
19	70%	65%	70%	69%	68%	71%	73%	76%	81%	74%	75%	76%	77%	67%
EUL =	20													

Table M-13. Full-Cost Adjustment Factors: Residential Refrigerators

	Refrigerator-E
	Res
	Median Ratio of Incremental Cost to Full Cost
	0.12
RUL	Full Cost Adjustment Factors
1	17%
2	21%
3	25%
4	29%
5	33%
6	36%
7	40%
8	43%
9	46%
10	48%
11	51%
12	54%
13	56%
14	58%
15	61%
16	63%
EUL =	17

Table M-14. Full-Cost Adjustment Factors: Central Air Conditioners, Air Source Heat Pumps, Non-Res Water Heaters, Indirect Water Heaters, and Air Compressor Upgrades

RUL	Central Air Conditioner/Air Source Heat Pumps (SEER 14)	Central Air Conditioner/Air Source Heat Pumps (SEER 15)	Central Air Conditioner/Air Source Heat Pumps (SEER 16)	Central Air Conditioner/Air Source Heat Pumps (SEER 17)	Central Air Conditioner/Air Source Heat Pumps (SEER 18)	DHW-E	DHW-G	Indirect Water Heater-G	Air Compressor Upgrade-E
	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Non-Res	Non-Res	Non-Res	Non-Res
	Median Ratio of Incremental Cost to Full Cost								
	0.10	0.20	0.26	0.31	0.37	0.25	0.22	0.93	0.46
	Full Cost Adjustment Factors								
1	15%	24%	30%	35%	40%	29%	26%	93%	49%
2	19%	28%	34%	38%	43%	33%	30%	94%	51%
3	23%	32%	37%	41%	46%	36%	34%	94%	54%
4	27%	35%	40%	44%	49%	39%	37%	94%	56%
5	31%	39%	43%	47%	52%	43%	40%	95%	59%
6	35%	42%	46%	50%	54%	46%	43%	95%	61%
7	38%	45%	49%	53%	57%	48%	46%	95%	63%
8	41%	48%	52%	55%	59%	51%	49%	95%	65%
9	44%	51%	54%	57%	61%	54%	52%	96%	67%
10	47%	53%	57%	60%	63%	56%	54%	96%	68%
11	50%	56%	59%	62%	65%	58%	57%	96%	70%
12	53%	58%	61%	64%	67%	61%	59%	96%	72%
13	55%	60%	63%	66%	69%	63%	61%	97%	73%
14	57%	62%	65%	67%	70%	65%	63%	97%	74%
EUL =	15								

Table M-15. Full-Cost Adjustment Factors: Multi-Family Clothes Washers

	Clothes Washer-G
	MF Res
	Median Ratio of Incremental Cost to Full Cost
	0.24
RUL	Full Cost Adjustment Factors
1	28%
2	32%
3	35%
4	39%
5	42%
6	45%
7	48%
8	50%
9	53%
10	56%
11	58%
12	60%
13	62%
EUL =	14

Table M-16. Full-Cost Adjustment Factors: Residential Electric and Indirect Water Heaters

RUL	DHW-E	Indirect Water Heater-G
	Res	Res
	Median Ratio of Incremental Cost to Full Cost	
	0.25	0.93
	Full Cost Adjustment Factors	
1	29%	93%
2	33%	94%
3	36%	94%
4	39%	94%
5	43%	95%
6	46%	95%
7	48%	95%
8	51%	95%
9	54%	96%
10	56%	96%
11	58%	96%
12	61%	96%
EUL =	13	

Table M-17. Full-Cost Adjustment Factors: Non-Residential Refrigerators

RUL	Refrigerator-E
	Non-Res
	Median Ratio of Incremental Cost to Full Cost
	0.05
	Full Cost Adjustment Factors
1	10%
2	15%
3	19%
4	23%
5	27%
6	31%
7	35%
8	38%
9	41%
10	44%
11	47%
EUL =	12

Table M-18. Full-Cost Adjustment Factors: Clothes Washers, Dishwashers, and Residential Gas Water Heaters

RUL	Clothes Washer-E	Dishwasher-E	DHW-G
	Res	Res	Res
	Median Ratio of Incremental Cost to Full Cost		
	0.24	0.06	0.22
	Full Cost Adjustment Factors		
1	28%	11%	26%
2	32%	16%	30%
3	35%	20%	34%
4	39%	24%	37%
5	42%	28%	40%
6	45%	32%	43%
7	48%	35%	46%
8	50%	39%	49%
9	53%	42%	52%
10	56%	45%	54%
EUL =	11		

Table M-19. Full-Cost Adjustment Factors: Heat Pump Water Heaters and Room A/C

RUL	Heat Pump Water Heater-E	Room Air Conditioner-E
	Res	Res
	Median Ratio of Incremental Cost to Full Cost	
	0.77	0.23
	Full Cost Adjustment Factors	
1	78%	27%
2	79%	31%
3	80%	34%
4	81%	38%
5	82%	41%
6	83%	44%
7	84%	47%
8	85%	50%
9	86%	52%
EUL =	10	

Table M-20. Adjusted EULs: Residential Boilers

	Boiler-G
	Res
	Median Ratio of Incremental Savings to Full Savings
	0.15
RUL	Adjusted EULs in Years
1	3
2	4
3	5
4	6
5	7
6	8
7	9
8	10
9	11
10	12
11	13
12	13
13	14
14	15
15	16
16	17
17	18
18	19
19	20
20	21
21	22
22	22
23	23
24	24
EUL =	25

Table M -21. Adjusted EULs: Chillers, Furnaces, Non-Residential Boilers, and High Performance Windows

RUL	Chiller: Air Cooled Recip and Screw	Chiller: Water Cooled Recip	Chiller: Water Cooled Screw < 150 ton	Chiller: Water Cooled Screw 150-300 ton	Chiller: Water Cooled Screw > 300 ton	Chiller: Water Cooled Centrifugal < 150 ton	Chiller: Water Cooled Centrifugal 150-300 ton	Chiller: Water Cooled Centrifugal > 300 ton	Boiler-G	Furnace-G (AFUE 90)	Furnace-G (AFUE 92)	Furnace-G (AFUE 94)	Furnace-G (AFUE 96)	High Performance Windows-G
	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res
	Median Ratio of Incremental Savings to Full Savings													
	0.50	0.15	0.37	0.31	0.69	0.58	0.38	0.31	0.27	0.44	0.48	0.51	0.54	0.63
	Adjusted EULs in Years													
1	8	3	6	5	12	10	6	5	5	7	8	8	9	11
2	9	4	7	6	12	10	7	6	5	8	9	9	10	11
3	10	5	8	7	13	11	8	7	6	9	9	10	10	12
4	10	6	9	8	13	12	9	8	7	10	10	11	11	12
5	11	7	9	9	14	12	9	9	8	10	11	11	12	13
6	12	8	10	9	14	13	10	9	9	11	11	12	12	14
7	12	8	11	10	15	13	11	10	10	12	12	13	13	14
8	13	9	12	11	15	14	12	11	11	12	13	13	14	15
9	14	10	12	12	16	15	12	12	11	13	13	14	14	15
10	14	11	13	13	16	15	13	13	12	14	14	14	15	16
11	15	12	14	13	17	16	14	13	13	14	15	15	15	16
12	16	13	15	14	17	16	15	14	14	15	15	16	16	17
13	16	14	15	15	18	17	15	15	15	16	16	16	16	17
14	17	15	16	16	18	17	16	16	15	16	17	17	17	18
15	17	16	17	16	18	18	17	16	16	17	17	17	18	18
16	18	17	17	17	19	18	17	17	17	18	18	18	18	18
17	18	17	18	18	19	19	18	18	18	18	18	18	19	19
18	19	18	19	19	19	19	19	19	19	19	19	19	19	19
19	20	19	19	19	20	20	19	19	19	19	19	20	20	20
EUL =	20													

Table M-22. Adjusted EULs: Residential Refrigerators

RUL	Refrigerator-E Res Median Ratio of Incremental Savings to Full Savings 0.11 Adjusted EULs in Years
1	2
2	3
3	4
4	5
5	6
6	7
7	8
8	9
9	10
10	11
11	12
12	12
13	13
14	14
15	15
16	16
EUL =	17

Table M-23. Adjusted EULs: Central Air Conditioners, Air Source Heat Pumps, Non-Res Water Heaters, Indirect Water Heaters, and Air Compressor Upgrades

RUL	Central Air Conditioner/Air Source Heat Pumps (SEER 14)	Central Air Conditioner/Air Source Heat Pumps (SEER 15)	Central Air Conditioner/Air Source Heat Pumps (SEER 16)	Central Air Conditioner/Air Source Heat Pumps (SEER 17)	Central Air Conditioner/Air Source Heat Pumps (SEER 18)	DHW-E	DHW-G	Indirect Water Heater-G	Air Compressor Upgrade-E
	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Res/Non-Res	Non-Res	Non-Res	Non-Res	Non-Res
	Median Ratio of Incremental Savings to Full Savings								
	0.19	0.31	0.38	0.44	0.48	0.60	0.21	0.34	0.48
	Adjusted EULs in Years								
1	3	4	6	6	7	8	4	5	6
2	4	5	6	7	7	9	4	6	7
3	5	6	7	7	8	9	5	6	8
4	6	7	7	8	9	10	6	7	9
5	7	8	8	9	9	10	7	8	9
6	7	8	9	9	10	11	8	9	10
7	8	9	10	10	10	11	8	9	10
8	9	10	10	11	11	12	9	10	11
9	10	11	11	11	12	12	10	11	12
10	11	11	12	12	12	13	11	12	12
11	12	12	12	13	13	13	12	12	13
12	13	13	13	13	13	14	13	13	13
13	13	14	14	14	14	14	13	14	14
14	14	14	14	14	14	15	14	14	14
EUL =	15								

TABLE M-24. ADJUSTED EULS: MULTI-FAMILY CLOTHES WASHERS

RUL	Clothes Washer-G
	MF Res
	Median Ratio of Incremental Savings to Full Savings
	0.39
	Adjusted EULs in Years
1	5
2	6
3	7
4	7
5	8
6	9
7	9
8	10
9	11
10	11
11	12
12	13
13	13
EUL =	14

TABLE M-25. ADJUSTED EULS: RESIDENTIAL ELECTRIC AND GAS INDIRECT WATER HEATERS

RUL	DHW-E	Indirect Water Heater-G
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.60	0.34
	Adjusted EULs in Years	
1	8	5
2	8	5
3	8	6
4	9	7
5	9	7
6	10	8
7	10	9
8	11	10
9	11	10
10	12	11
11	12	12
12	13	12
EUL =	13	

TABLE M-26. ADJUSTED EULS: NON-RESIDENTIAL REFRIGERATORS

RUL	Refrigerator-E
	Non-Res
	Median Ratio of Incremental Savings to Full Savings
	0.34
	Adjusted EULs in Years
1	4
2	5
3	6
4	6
5	7
6	8
7	9
8	9
9	10
10	11
11	11
EUL =	12

Table M-27. Adjusted EULs: Clothes Washers, Dishwashers, and Residential Gas Water Heaters

RUL	Clothes Washer-E	Dishwasher-E	DHW-G
	Res	Res	Res
	Median Ratio of Incremental Savings to Full Savings		
	0.39	0.33	0.21
	Adjusted EULs in Years		
1	4	4	3
2	5	5	4
3	6	5	4
4	6	6	5
5	7	7	6
6	8	8	7
7	8	8	8
8	9	9	9
9	10	10	9
10	10	10	10
EUL =	11		

Table M-28. Adjusted EULs: Heat Pump Water Heaters and Room A/C

RUL	Heat Pump Water Heater-E	Room Air Conditioner-E
	Res	Res
	Median Ratio of Incremental Savings to Full Savings	
	0.87	0.25
	Adjusted EULs in Years	
1	9	3
2	9	4
3	9	5
4	9	5
5	9	6
6	9	7
7	10	8
8	10	8
9	10	9
EUL =	10	

Table M-29. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 25 Year EUL

	Savings																		
RU	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9
1	14	14	20	26	32	37	42	42	47	52	60	64	68	71	78	81	86	91	96
2	20	20	26	32	37	42	42	47	52	56	60	64	71	75	78	84	86	91	96
3	26	26	32	37	42	42	47	52	56	60	64	68	71	75	81	84	89	91	96
4	32	32	37	42	47	47	52	56	60	64	68	71	75	78	81	86	89	94	96
5	37	37	42	47	47	52	56	60	64	68	68	71	75	81	84	86	89	94	96
6	42	42	47	52	52	56	60	64	64	68	71	75	78	81	84	86	91	94	96
7	47	47	52	52	56	60	64	64	68	71	75	78	81	84	86	89	91	94	98
8	52	52	56	56	60	64	64	68	71	75	75	78	81	84	86	89	91	94	98
9	56	56	60	60	64	68	68	71	75	75	78	81	84	86	89	91	94	96	98
1	60	60	64	64	68	68	71	75	75	78	81	84	84	86	89	91	94	96	98
1	64	64	68	68	71	71	75	75	78	81	81	84	86	89	89	91	94	96	98
1	64	68	68	71	75	75	78	78	81	81	84	86	86	89	91	94	94	96	98
1	68	71	71	75	75	78	78	81	81	84	86	86	89	91	91	94	96	96	98
1	71	75	75	78	78	81	81	84	84	86	86	89	89	91	94	94	96	98	98
1	75	78	78	81	81	81	84	84	86	86	89	89	91	91	94	96	96	98	98
1	78	81	81	81	84	84	86	86	89	89	89	91	91	94	94	96	96	98	98
1	81	84	84	84	86	86	86	89	89	91	91	91	94	94	96	96	98	98	100
1	84	86	86	86	89	89	89	91	91	91	94	94	94	96	96	96	98	98	100
1	86	89	89	89	89	91	91	91	91	94	94	94	96	96	96	98	98	98	100
2	89	89	91	91	91	91	94	94	94	94	96	96	96	96	98	98	98	98	100
2	91	91	94	94	94	94	94	96	96	96	96	96	98	98	98	98	98	100	100
2	94	94	94	96	96	96	96	96	96	96	98	98	98	98	98	98	100	100	100
2	96	96	96	96	96	98	98	98	98	98	98	98	98	98	98	100	100	100	100
2	98	98	98	98	98	98	98	98	98	100	100	100	100	100	100	100	100	100	100
EUL	2																		

Table M-30. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 20 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	16%	16%	23%	29%	29%	36%	42%	47%	47%	53%	58%	63%	67%	72%	76%	80%	87%	91%	94%
2	23%	23%	29%	29%	36%	42%	47%	47%	53%	58%	63%	67%	72%	76%	80%	84%	87%	91%	97%
3	29%	29%	36%	36%	42%	47%	47%	53%	58%	63%	67%	67%	72%	76%	80%	84%	87%	91%	97%
4	36%	36%	42%	42%	47%	53%	53%	58%	63%	63%	67%	72%	76%	80%	84%	87%	91%	94%	97%
5	42%	42%	47%	47%	53%	53%	58%	63%	63%	67%	72%	76%	76%	80%	84%	87%	91%	94%	97%
6	47%	47%	53%	53%	58%	58%	63%	63%	67%	72%	72%	76%	80%	84%	84%	87%	91%	94%	97%
7	47%	53%	53%	58%	63%	63%	67%	67%	72%	72%	76%	80%	80%	84%	87%	91%	91%	94%	97%
8	53%	58%	58%	63%	63%	67%	67%	72%	76%	76%	80%	80%	84%	87%	87%	91%	94%	94%	97%
9	58%	63%	63%	67%	67%	72%	72%	76%	76%	80%	80%	84%	84%	87%	91%	91%	94%	97%	97%
10	63%	67%	67%	72%	72%	72%	76%	76%	80%	80%	84%	84%	87%	87%	91%	94%	94%	97%	97%
11	67%	72%	72%	72%	76%	76%	80%	80%	84%	84%	84%	87%	87%	91%	91%	94%	94%	97%	97%
12	72%	76%	76%	76%	80%	80%	80%	84%	84%	87%	87%	87%	91%	91%	94%	94%	97%	97%	100%
13	76%	80%	80%	80%	84%	84%	84%	87%	87%	87%	91%	91%	91%	94%	94%	94%	97%	97%	100%
14	80%	84%	84%	84%	84%	87%	87%	87%	87%	91%	91%	91%	94%	94%	94%	97%	97%	97%	100%
15	84%	84%	87%	87%	87%	87%	91%	91%	91%	91%	94%	94%	94%	94%	97%	97%	97%	97%	100%
16	87%	87%	91%	91%	91%	91%	91%	94%	94%	94%	94%	94%	97%	97%	97%	97%	97%	100%	100%
17	91%	91%	91%	94%	94%	94%	94%	94%	94%	94%	97%	97%	97%	97%	97%	97%	100%	100%	100%
18	94%	94%	94%	94%	94%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	100%	100%	100%	100%
19	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	20																		

Table M-31. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 17 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	17%	17%	25%	25%	32%	39%	39%	46%	52%	52%	58%	64%	69%	74%	79%	84%	88%	92%	96%
2	25%	25%	32%	32%	39%	39%	46%	52%	52%	58%	64%	69%	69%	74%	79%	84%	88%	92%	96%
3	32%	32%	39%	39%	46%	46%	52%	52%	58%	64%	64%	69%	74%	79%	79%	84%	88%	92%	96%
4	32%	39%	39%	46%	52%	52%	58%	58%	64%	64%	69%	74%	74%	79%	84%	88%	88%	92%	96%
5	39%	46%	46%	52%	52%	58%	58%	64%	69%	69%	74%	74%	79%	84%	84%	88%	92%	92%	96%
6	46%	52%	52%	58%	58%	64%	64%	69%	69%	74%	74%	79%	79%	84%	88%	88%	92%	96%	96%
7	52%	58%	58%	64%	64%	69%	69%	69%	74%	74%	79%	79%	84%	84%	88%	92%	92%	96%	96%
8	58%	64%	64%	69%	69%	69%	74%	74%	79%	79%	79%	84%	84%	88%	88%	92%	92%	96%	96%
9	64%	69%	69%	69%	74%	74%	74%	79%	79%	84%	84%	84%	88%	88%	92%	92%	96%	96%	100%
10	69%	74%	74%	74%	79%	79%	79%	84%	84%	84%	88%	88%	88%	92%	92%	92%	96%	96%	100%
11	74%	79%	79%	79%	79%	84%	84%	84%	84%	88%	88%	88%	92%	92%	92%	96%	96%	96%	100%
12	79%	79%	84%	84%	84%	84%	88%	88%	88%	88%	92%	92%	92%	92%	96%	96%	96%	96%	100%
13	84%	84%	88%	88%	88%	88%	88%	92%	92%	92%	92%	92%	96%	96%	96%	96%	96%	100%	100%
14	88%	88%	88%	92%	92%	92%	92%	92%	92%	92%	96%	96%	96%	96%	96%	96%	100%	100%	100%
15	92%	92%	92%	92%	92%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	100%	100%	100%	100%
16	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	17																		

Table M-32. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 15 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	19%	19%	27%	27%	35%	35%	43%	43%	50%	56%	56%	63%	69%	75%	75%	80%	86%	91%	95%
2	19%	27%	27%	35%	43%	43%	50%	50%	56%	56%	63%	69%	69%	75%	80%	86%	86%	91%	95%
3	27%	35%	35%	43%	43%	50%	50%	56%	63%	63%	69%	69%	75%	80%	80%	86%	91%	91%	95%
4	35%	43%	43%	50%	50%	56%	56%	63%	63%	69%	69%	75%	75%	80%	86%	86%	91%	95%	95%
5	43%	50%	50%	56%	56%	63%	63%	63%	69%	69%	75%	75%	80%	80%	86%	91%	91%	95%	95%
6	50%	56%	56%	63%	63%	63%	69%	69%	75%	75%	75%	80%	80%	86%	86%	91%	91%	95%	95%
7	56%	63%	63%	63%	69%	69%	69%	75%	75%	80%	80%	80%	86%	86%	91%	91%	95%	95%	100%
8	63%	69%	69%	69%	75%	75%	75%	80%	80%	80%	86%	86%	86%	91%	91%	91%	95%	95%	100%
9	69%	75%	75%	75%	75%	80%	80%	80%	80%	86%	86%	86%	91%	91%	91%	95%	95%	95%	100%
10	75%	75%	80%	80%	80%	80%	86%	86%	86%	86%	91%	91%	91%	91%	95%	95%	95%	95%	100%
11	80%	80%	86%	86%	86%	86%	86%	91%	91%	91%	91%	91%	95%	95%	95%	95%	95%	100%	100%
12	86%	86%	86%	91%	91%	91%	91%	91%	91%	91%	95%	95%	95%	95%	95%	95%	100%	100%	100%
13	91%	91%	91%	91%	91%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%
14	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	15																		

Table M-33. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 14 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	10%	19%	19%	28%	37%	37%	45%	45%	52%	52%	59%	66%	66%	72%	78%	84%	84%	90%	95%
2	19%	28%	28%	37%	37%	45%	45%	52%	59%	59%	66%	66%	72%	78%	78%	84%	90%	90%	95%
3	28%	37%	37%	45%	45%	52%	52%	59%	59%	66%	66%	72%	72%	78%	84%	84%	90%	95%	95%
4	37%	45%	45%	52%	52%	59%	59%	59%	66%	66%	72%	72%	78%	78%	84%	90%	90%	95%	95%
5	45%	52%	52%	59%	59%	59%	66%	66%	72%	72%	72%	78%	78%	84%	84%	90%	90%	95%	95%
6	52%	59%	59%	59%	66%	66%	66%	72%	72%	78%	78%	78%	84%	84%	90%	90%	95%	95%	100%
7	59%	66%	66%	66%	72%	72%	72%	78%	78%	78%	84%	84%	84%	90%	90%	90%	95%	95%	100%
8	66%	72%	72%	72%	72%	78%	78%	78%	78%	84%	84%	84%	90%	90%	90%	95%	95%	95%	100%
9	72%	72%	78%	78%	78%	78%	84%	84%	84%	84%	90%	90%	90%	90%	95%	95%	95%	95%	100%
10	78%	78%	84%	84%	84%	84%	84%	90%	90%	90%	90%	90%	95%	95%	95%	95%	95%	100%	100%
11	84%	84%	84%	90%	90%	90%	90%	90%	90%	90%	95%	95%	95%	95%	95%	95%	100%	100%	100%
12	90%	90%	90%	90%	90%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%
13	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	14																		

Table M-34. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 13 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	11%	20%	20%	30%	30%	39%	39%	47%	55%	55%	62%	62%	69%	76%	76%	83%	89%	89%	94%
2	20%	30%	30%	39%	39%	47%	47%	55%	55%	62%	62%	69%	69%	76%	83%	83%	89%	94%	94%
3	30%	39%	39%	47%	47%	55%	55%	55%	62%	62%	69%	69%	76%	76%	83%	89%	89%	94%	94%
4	39%	47%	47%	55%	55%	55%	62%	62%	69%	69%	69%	76%	76%	83%	83%	89%	89%	94%	94%
5	47%	55%	55%	55%	62%	62%	62%	69%	69%	76%	76%	76%	83%	83%	89%	89%	94%	94%	100%
6	55%	62%	62%	62%	69%	69%	69%	76%	76%	76%	83%	83%	83%	89%	89%	89%	94%	94%	100%
7	62%	69%	69%	69%	69%	76%	76%	76%	76%	83%	83%	83%	89%	89%	89%	94%	94%	94%	100%
8	69%	69%	76%	76%	76%	76%	83%	83%	83%	83%	89%	89%	89%	89%	94%	94%	94%	94%	100%
9	76%	76%	83%	83%	83%	83%	83%	89%	89%	89%	89%	89%	94%	94%	94%	94%	94%	100%	100%
10	83%	83%	83%	89%	89%	89%	89%	89%	89%	89%	94%	94%	94%	94%	94%	94%	100%	100%	100%
11	89%	89%	89%	89%	89%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%
12	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	13																		

Table M-35. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 12 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	11%	22%	22%	32%	32%	41%	41%	50%	50%	58%	58%	66%	66%	73%	81%	81%	87%	94%	94%
2	22%	32%	32%	41%	41%	41%	50%	50%	58%	58%	66%	66%	73%	73%	81%	87%	87%	94%	94%
3	32%	41%	41%	41%	50%	50%	58%	58%	66%	66%	66%	73%	73%	81%	81%	87%	87%	94%	94%
4	41%	50%	50%	50%	58%	58%	58%	66%	66%	73%	73%	73%	81%	81%	87%	87%	94%	94%	100%
5	50%	58%	58%	58%	66%	66%	66%	73%	73%	73%	81%	81%	81%	87%	87%	87%	94%	94%	100%
6	58%	66%	66%	66%	66%	73%	73%	73%	73%	81%	81%	81%	87%	87%	87%	94%	94%	94%	100%
7	66%	66%	73%	73%	73%	73%	81%	81%	81%	81%	87%	87%	87%	87%	94%	94%	94%	94%	100%
8	73%	73%	81%	81%	81%	81%	81%	87%	87%	87%	87%	87%	94%	94%	94%	94%	94%	100%	100%
9	81%	81%	81%	87%	87%	87%	87%	87%	87%	87%	94%	94%	94%	94%	94%	94%	100%	100%	100%
10	87%	87%	87%	87%	87%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%
11	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	12																		

Table M-36. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for an 11 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	12%	23%	23%	34%	34%	34%	43%	43%	53%	53%	62%	62%	70%	70%	78%	86%	86%	93%	93%
2	23%	34%	34%	34%	43%	43%	53%	53%	62%	62%	62%	70%	70%	78%	78%	86%	86%	93%	93%
3	34%	43%	43%	43%	53%	53%	53%	62%	62%	70%	70%	70%	78%	78%	86%	86%	93%	93%	100%
4	43%	53%	53%	53%	62%	62%	62%	70%	70%	70%	78%	78%	78%	86%	86%	86%	93%	93%	100%
5	53%	62%	62%	62%	62%	70%	70%	70%	70%	78%	78%	78%	86%	86%	86%	93%	93%	93%	100%
6	62%	62%	70%	70%	70%	70%	78%	78%	78%	78%	86%	86%	86%	86%	93%	93%	93%	93%	100%
7	70%	70%	78%	78%	78%	78%	78%	86%	86%	86%	86%	86%	93%	93%	93%	93%	93%	100%	100%
8	78%	78%	78%	86%	86%	86%	86%	86%	86%	86%	93%	93%	93%	93%	93%	93%	100%	100%	100%
9	86%	86%	86%	86%	86%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	100%	100%	100%	100%
10	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	11																		

Table M-37. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings for a 10 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	13%	25%	25%	25%	36%	36%	47%	47%	57%	57%	57%	66%	66%	75%	75%	84%	84%	92%	92%
2	25%	36%	36%	36%	47%	47%	47%	57%	57%	66%	66%	66%	75%	75%	84%	84%	92%	92%	100%
3	36%	47%	47%	47%	57%	57%	57%	66%	66%	66%	75%	75%	75%	84%	84%	84%	92%	92%	100%
4	47%	57%	57%	57%	57%	66%	66%	66%	66%	75%	75%	75%	84%	84%	84%	92%	92%	92%	100%
5	57%	57%	66%	66%	66%	66%	75%	75%	75%	75%	84%	84%	84%	84%	92%	92%	92%	92%	100%
6	66%	66%	75%	75%	75%	75%	75%	84%	84%	84%	84%	84%	92%	92%	92%	92%	92%	100%	100%
7	75%	75%	75%	84%	84%	84%	84%	84%	84%	84%	92%	92%	92%	92%	92%	92%	100%	100%	100%
8	84%	84%	84%	84%	84%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	100%	100%	100%	100%
9	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EUL =	10																		

Table M-38. Full Cost Adjustment Factors

	Cost Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	10%	15%	19%	24%	29%	34%	38%	43%	48%	53%	57%	62%	67%	72%	76%	81%	86%	91%	95%
2	15%	19%	24%	28%	33%	37%	42%	46%	51%	55%	60%	64%	69%	73%	78%	82%	87%	91%	96%
3	19%	23%	28%	32%	36%	40%	45%	49%	53%	57%	62%	66%	70%	74%	79%	83%	87%	91%	96%
4	23%	27%	31%	35%	39%	43%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%
5	27%	31%	35%	39%	43%	46%	50%	54%	58%	62%	66%	69%	73%	77%	81%	85%	89%	92%	96%
6	31%	35%	38%	42%	46%	49%	53%	56%	60%	64%	67%	71%	75%	78%	82%	85%	89%	93%	96%
7	35%	38%	42%	45%	48%	52%	55%	59%	62%	66%	69%	73%	76%	79%	83%	86%	90%	93%	97%
8	38%	41%	45%	48%	51%	54%	58%	61%	64%	67%	71%	74%	77%	80%	84%	87%	90%	93%	97%
9	41%	44%	48%	51%	54%	57%	60%	63%	66%	69%	72%	75%	78%	81%	85%	88%	91%	94%	97%
10	44%	47%	50%	53%	56%	59%	62%	65%	68%	71%	74%	77%	80%	82%	85%	88%	91%	94%	97%
11	47%	50%	53%	56%	58%	61%	64%	67%	69%	72%	75%	78%	81%	83%	86%	89%	92%	94%	97%
12	50%	53%	55%	58%	61%	63%	66%	68%	71%	74%	76%	79%	82%	84%	87%	89%	92%	95%	97%
13	53%	55%	58%	60%	63%	65%	68%	70%	73%	75%	78%	80%	83%	85%	88%	90%	93%	95%	98%
14	55%	57%	60%	62%	65%	67%	69%	72%	74%	76%	79%	81%	83%	86%	88%	91%	93%	95%	98%
15	57%	60%	62%	64%	66%	69%	71%	73%	75%	78%	80%	82%	84%	87%	89%	91%	93%	96%	98%
16	60%	62%	64%	66%	68%	70%	72%	75%	77%	79%	81%	83%	85%	87%	89%	92%	94%	96%	98%
17	62%	64%	66%	68%	70%	72%	74%	76%	78%	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%
18	64%	66%	68%	69%	71%	73%	75%	77%	79%	81%	83%	85%	87%	89%	90%	92%	94%	96%	98%
19	66%	67%	69%	71%	73%	75%	76%	78%	80%	82%	84%	86%	87%	89%	91%	93%	95%	96%	98%
20	67%	69%	71%	73%	74%	76%	78%	79%	81%	83%	85%	86%	88%	90%	91%	93%	95%	97%	98%
21	69%	71%	72%	74%	76%	77%	79%	81%	82%	84%	85%	87%	89%	90%	92%	94%	95%	97%	98%
22	71%	72%	74%	75%	77%	78%	80%	82%	83%	85%	86%	88%	89%	91%	92%	94%	95%	97%	98%
23	72%	74%	75%	77%	78%	80%	81%	82%	84%	85%	87%	88%	90%	91%	93%	94%	96%	97%	99%
24	74%	75%	76%	78%	79%	81%	82%	83%	85%	86%	88%	89%	90%	92%	93%	94%	96%	97%	99%
EUL =	25																		

Table M-39. Adjusted EULs for a 25 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	2	2	3	4	5	6	7	7	8	9	11	12	13	14	16	17	19	21	23
2	3	3	4	5	6	7	7	8	9	10	11	12	14	15	16	18	19	21	23
3	4	4	5	6	7	7	8	9	10	11	12	13	14	15	17	18	20	21	23
4	5	5	6	7	8	8	9	10	11	12	13	14	15	16	17	19	20	22	23
5	6	6	7	8	8	9	10	11	12	13	13	14	15	17	18	19	20	22	23
6	7	7	8	9	9	10	11	12	12	13	14	15	16	17	18	19	21	22	23
7	8	8	9	9	10	11	12	12	13	14	15	16	17	18	19	20	21	22	24
8	9	9	10	10	11	12	12	13	14	15	15	16	17	18	19	20	21	22	24
9	10	10	11	11	12	13	13	14	15	15	16	17	18	19	20	21	22	23	24
10	11	11	12	12	13	13	14	15	15	16	17	18	18	19	20	21	22	23	24
11	12	12	13	13	14	14	15	15	16	17	17	18	19	20	20	21	22	23	24
12	12	13	13	14	15	15	16	16	17	17	18	19	19	20	21	22	22	23	24
13	13	14	14	15	15	16	16	17	17	18	19	19	20	21	21	22	23	23	24
14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	22	22	23	24	24
15	15	16	16	17	17	17	18	18	19	19	20	20	21	21	22	23	23	24	24
16	16	17	17	17	18	18	19	19	20	20	20	21	21	22	22	23	23	24	24
17	17	18	18	18	19	19	19	20	20	21	21	21	22	22	23	23	24	24	25
18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24	24	25
19	19	20	20	20	20	21	21	21	21	22	22	22	23	23	23	24	24	24	25
20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25
21	21	21	22	22	22	22	22	23	23	23	23	23	24	24	24	24	24	25	25
22	22	22	22	23	23	23	23	23	23	23	24	24	24	24	24	24	25	25	25
23	23	23	23	23	23	24	24	24	24	24	24	24	24	24	24	25	25	25	25
24	24	24	24	24	24	24	24	24	24	25	25	25	25	25	25	25	25	25	25
EUL =	**25**																		

Table M-40. Adjusted EULs for a 20 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	2	2	3	4	4	5	6	7	7	8	9	10	11	12	13	14	16	17	18
2	3	3	4	4	5	6	7	7	8	9	10	11	12	13	14	15	16	17	19
3	4	4	5	5	6	7	7	8	9	10	11	11	12	13	14	15	16	17	19
4	5	5	6	6	7	8	8	9	10	10	11	12	13	14	15	16	17	18	19
5	6	6	7	7	8	8	9	10	10	11	12	13	13	14	15	16	17	18	19
6	7	7	8	8	9	9	10	10	11	12	12	13	14	15	15	16	17	18	19
7	7	8	8	9	10	10	11	11	12	12	13	14	14	15	16	17	17	18	19
8	8	9	9	10	10	11	11	12	13	13	14	14	15	16	16	17	18	18	19
9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	17	17	18	19	19
10	10	11	11	12	12	12	13	13	14	14	15	15	16	16	17	18	18	19	19
11	11	12	12	12	13	13	14	14	15	15	15	16	16	17	17	18	18	19	19
12	12	13	13	13	14	14	14	15	15	16	16	16	17	17	18	18	19	19	20
13	13	14	14	14	15	15	15	16	16	16	17	17	17	18	18	18	19	19	20
14	14	15	15	15	15	16	16	16	16	17	17	17	18	18	18	19	19	19	20
15	15	15	16	16	16	16	17	17	17	17	18	18	18	18	19	19	19	19	20
16	16	16	17	17	17	17	17	18	18	18	18	18	19	19	19	19	19	20	20
17	17	17	17	18	18	18	18	18	18	18	19	19	19	19	19	19	20	20	20
18	18	18	18	18	18	19	19	19	19	19	19	19	19	19	19	20	20	20	20
19	19	19	19	19	19	19	19	19	19	19	20	20	20	20	20	20	20	20	20
EUL =	20																		

Table M-41. Adjusted EULs for a 17 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	2	2	3	3	4	5	5	6	7	7	8	9	10	11	12	13	14	15	16
2	3	3	4	4	5	5	6	7	7	8	9	10	10	11	12	13	14	15	16
3	4	4	5	5	6	6	7	7	8	9	9	10	11	12	12	13	14	15	16
4	4	5	5	6	7	7	8	8	9	9	10	11	11	12	13	14	14	15	16
5	5	6	6	7	7	8	8	9	10	10	11	11	12	13	13	14	15	15	16
6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	16	16
7	7	8	8	9	9	10	10	10	11	11	12	12	13	13	14	15	15	16	16
8	8	9	9	10	10	10	11	11	12	12	12	13	13	14	14	15	15	16	16
9	9	10	10	10	11	11	11	12	12	13	13	13	14	14	15	15	16	16	17
10	10	11	11	11	12	12	12	13	13	13	14	14	14	15	15	15	16	16	17
11	11	12	12	12	12	13	13	13	13	14	14	14	15	15	15	16	16	16	17
12	12	12	13	13	13	13	14	14	14	14	15	15	15	15	16	16	16	16	17
13	13	13	14	14	14	14	14	15	15	15	15	15	16	16	16	16	16	17	17
14	14	14	14	15	15	15	15	15	15	15	16	16	16	16	16	16	17	17	17
15	15	15	15	15	15	16	16	16	16	16	16	16	16	16	16	17	17	17	17
16	16	16	16	16	16	16	16	16	16	16	17	17	17	17	17	17	17	17	17
EUL =	17																		

Table M-42. Adjusted EULs for a 15 Year EUL

	Savings Ratio																		
RUL	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**
1	2	2	3	3	4	4	5	5	6	7	7	8	9	10	10	11	12	13	14
2	2	3	3	4	5	5	6	6	7	7	8	9	9	10	11	12	12	13	14
3	3	4	4	5	5	6	6	7	8	8	9	9	10	11	11	12	13	13	14
4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	12	12	13	14	14
5	5	6	6	7	7	8	8	8	9	9	10	10	11	11	12	13	13	14	14
6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	12	13	13	14	14
7	7	8	8	8	9	9	9	10	10	11	11	11	12	12	13	13	14	14	15
8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	13	14	14	15
9	9	10	10	10	10	11	11	11	11	12	12	12	13	13	13	14	14	14	15
10	10	10	11	11	11	11	12	12	12	12	13	13	13	13	14	14	14	14	15
11	11	11	12	12	12	12	12	13	13	13	13	13	14	14	14	14	14	15	15
12	12	12	12	13	13	13	13	13	13	13	14	14	14	14	14	14	15	15	15
13	13	13	13	13	13	14	14	14	14	14	14	14	14	14	14	15	15	15	15
14	14	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	15	15
EUL =	**15**																		

Table M-43. Adjusted EULs for a 14 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	4	4	5	5	6	6	7	8	8	9	10	11	11	12	13
2	2	3	3	4	4	5	5	6	7	7	8	8	9	10	10	11	12	12	13
3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	11	11	12	13	13
4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	12	12	13	13
5	5	6	6	7	7	7	8	8	9	9	9	10	10	11	11	12	12	13	13
6	6	7	7	7	8	8	8	9	9	10	10	10	11	11	12	12	13	13	14
7	7	8	8	8	9	9	9	10	10	10	11	11	11	12	12	12	13	13	14
8	8	9	9	9	9	10	10	10	10	11	11	11	12	12	12	13	13	13	14
9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13	13	13	13	14
10	10	10	11	11	11	11	11	12	12	12	12	12	13	13	13	13	13	14	14
11	11	11	11	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14
12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14
13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	14
EUL =	14																		

Table M-44. Adjusted EULs for a 13 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	3	4	4	5	6	6	7	7	8	9	9	10	11	11	12
2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	10	10	11	12	12
3	3	4	4	5	5	6	6	6	7	7	8	8	9	9	10	11	11	12	12
4	4	5	5	6	6	6	7	7	8	8	8	9	9	10	10	11	11	12	12
5	5	6	6	6	7	7	7	8	8	9	9	9	10	10	11	11	12	12	13
6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	11	12	12	13
7	7	8	8	8	8	9	9	9	9	10	10	10	11	11	11	12	12	12	13
8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13
9	9	9	10	10	10	10	10	11	11	11	11	11	12	12	12	12	12	13	13
10	10	10	10	11	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13
11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	13	13	13	13
12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13
EUL =	13																		

Table M-45. Adjusted EULs for a 12 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	9	9	10	11	11
2	2	3	3	4	4	4	5	5	6	6	7	7	8	8	9	10	10	11	11
3	3	4	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	11
4	4	5	5	5	6	6	6	7	7	8	8	8	9	9	10	10	11	11	12
5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	12
6	6	7	7	7	7	8	8	8	8	9	9	9	10	10	10	11	11	11	12
7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12
8	8	8	9	9	9	9	9	10	10	10	10	10	11	11	11	11	11	12	12
9	9	9	9	10	10	10	10	10	10	10	11	11	11	11	11	11	12	12	12
10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	12	12	12	12
11	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12
EUL =	12																		

Table M-46. Adjusted EULs for a 11 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	3	3	3	4	4	5	5	6	6	7	7	8	9	9	10	10
2	2	3	3	3	4	4	5	5	6	6	6	7	7	8	8	9	9	10	10
3	3	4	4	4	5	5	5	6	6	7	7	7	8	8	9	9	10	10	11
4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	11
5	5	6	6	6	6	7	7	7	7	8	8	8	9	9	9	10	10	10	11
6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11
7	7	7	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	11	11
8	8	8	8	9	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11
9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	11	11	11	11
10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11
EUL =	11																		

Table M-47. Adjusted EULs for a 10 Year EUL

	Savings Ratio																		
RUL	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	2	2	2	3	3	4	4	5	5	5	6	6	7	7	8	8	9	9
2	2	3	3	3	4	4	4	5	5	6	6	6	7	7	8	8	9	9	10
3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	10
4	4	5	5	5	5	6	6	6	6	7	7	7	8	8	8	9	9	9	10
5	5	5	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10
6	6	6	7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	10	10
7	7	7	7	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10
8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	10	10	10	10
9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10
EUL =	10																		

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
5-11-1	5/6/2011

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APPENDIX N

SPECIAL CIRCUMSTANCE

Introduction

In its October 18, 2010 order[81], the Commission defined early replacement as replacement of equipment prior to the end of its prescribed effective-useful life and directed Staff to develop a dual baseline method for estimating the benefits and costs of early replacement that provides consistency between the treatment of savings and costs. The order also directed Staff to provide simplifying lookup tables for early replacement energy savings consistent with the dual baseline concept. The dual baseline methods and lookup tables have been developed and are provided in Appendix M of the Technical Manual.

The October 18, 2010 Order also introduced the concept of "special circumstance" replacements: the replacement of equipment operated by customers who are influenced by initial costs more than by life cycle economics. These customers include those with insufficient capital, a split incentive (such as a landlord incurring cost to provide a tenant benefit), short time horizons, and/or other factors which tend to prevent long range economic decision-making regarding the installation of high efficiency equipment. The Commission applied the concept of special circumstance replacements only to commercial and industrial machinery and multi-family central systems,[82] and only to equipment well past its prescribed effective useful life. The order specifically excluded lighting equipment from special circumstance replacement.

The Commission established a general outline for determining eligibility for special circumstance replacement treatment including:

Equipment age significantly exceeds its effective useful-life;
Energy consumption significantly exceeds that of current high efficiency models;
There is a history of significant repair or replacement with used equipment;
The prospective next repair or replacement is likely to be much less expensive than replacement with new higher efficiency machinery.

The order directed Staff to develop more detailed criteria and a method for adapting dual baseline screening for early replacement to special circumstance replacements, with consultation with the Evaluation Advisory Group (EAG) that includes the program administrators (PAs). In dual baseline analysis, the savings for the first baseline are calculated against the replaced equipment, while the savings for the second baseline are calculated against the current standards/codes minimums or, in the absence of such, common practice.

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[81] Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Consolidation and Revision of
Technical Manuals (issued October 18, 2010).

[82] What "multi-family central systems" includes is clarified in detail in the Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Modifications to the Technical Manual (issued July 18, 2011), pp 15 -16.

In the July 18, 2011 order,[83] the Commission approved Staff‟s proposals regarding detailing the first two criteria for eligibility:[84]

> **Age Rule**: The equipment to be replaced must be aged at least 125% of it is prescribed effective-useful life in cases where the age of the equipment can be determined to this extent.[85] If the equipment is determined to be less than 125% of its EUL, it‟s not eligible for SC treatment regardless of consumption or any other factor
>
> **Energy Use Rule**: Applies **only** in cases in which the age of the existing equipment cannot be determined relative to 125%; existing equipment of most types must consume at least 20% more energy than the new high efficiency equipment to do the same amount of work, and at least 35% more for chillers.

In the July 18 Order, the Commission also approved Staff‟s proposal to define the first baseline, the hypothetical period for which the old equipment in place would have continued in use absent the program (the Default Functional Period or DFP) as 25% of the program efficient measure‟s EUL.[86]

The July 18, 2011 order also directed Staff to post directions and lookup tables for Special Circumstance replacement as a counterpart to those in Appendix M for early replacement. For the interim period, PAs were permitted to use the tables in Appendix M for Special Circumstances for costs. [87] However, Appendix N includes tables for special circumstance replacement that PAs must now use.

For equipment that qualifies as special circumstance, the dual baseline method described in Appendix M will be applied for special circumstance TRC screening. The dual baseline situation that characterizes the special circumstance situation, illustrated in Figure 1, involves a customer who replaces fully functioning equipment aged at least 25% beyond its official EUL. The equipment hypothetically would have continued to function for some period of time, the DFP. However, the customer is induced by the program to replace this existing equipment with more efficient equipment. It is assumed that at the end of the DFP, absent the program, the

[83] Ibid.

[114] While the first two require definition of "significant," the third and fourth do not require or lend themselves to additional detail. The Commission also approved Staff‟s proposed relationship between the first two, i.e., energy consumption is considered only if age relative to 125% cannot be determined.

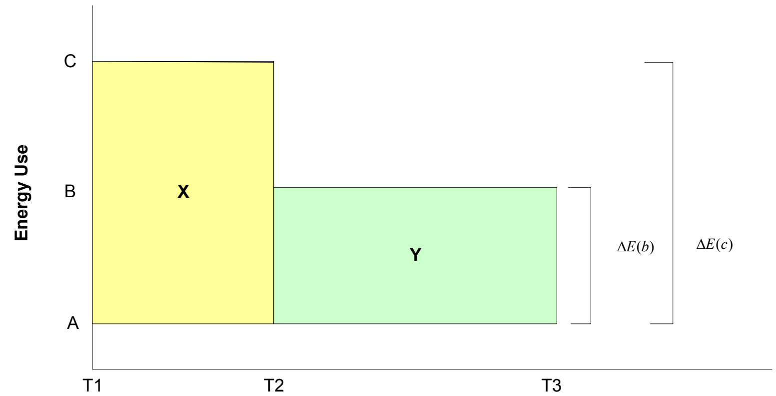
[85] It is not necessary to determine the exact age of the equipment as long as it can be determined to be at least 125% of the effective-useful life.

[86] The Order also included a comprehensive list of measures and associated EULs that should be used in cases where the special circumstance measure matches a measure in the Order. In cases where there is no match, PAs must propose and document the EUL.

[87] Program administrators were required to research and calculate their own **savings** ratios and to use the second set of tables (not the DEER-based tables), as consumption of the old equipment in place may differ between early and special circumstance replacement -- the baseline existing equipment is pre EUL versus 125% past it, potentially with widely varying efficiency. For costs, the comparison is between current high efficiency versus standards/code or common practice in any case.

customer would have installed equipment that would meet the existing efficiency code or appliance standard, or common practice (referred to as the *code/standard equipment*).

Figure 2. The Special Circumstance Condition



$\Delta E(c)$ = C - A
$\Delta E(b)$ = B - A
C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3= Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected period of time in which the pre-existing equipment would have continued to function, referred to as the default functional period (DFP)
T3 – T2 = Expected remaining EUL of the new efficient equipment

Energy savings in this example would consist of two portions. The customer would have experienced the ***full*** savings represented by the line segment C-A for the DFP period T2-T1, Area **X**. At the end of the DFP, the savings for the period T3-T2 would be reduced to ***incremental*** savings represented by the line segment B – A, area **Y**. To carry out these calculations, information on the energy use of code/standard equipment is required. Information on energy use of the existing equipment and the high efficiency equipment provided through the program is also required, but much more available and routinely needed.

The costs also have to be calculated in a manner consistent with the special circumstance case. In normal replacement situations, one would use the incremental cost that is defined as the cost of the new efficient equipment minus the cost of the code/standard equipment. In the special circumstance case, the incremental cost is calculated in a slightly different manner, which recognizes, in the absence of the program, the customer would not have purchased any equipment until the future end of the DFP.

Thus, one would first have to determine the full cost of the new efficient equipment at T1 *and* the full cost of the code/standard equipment (both including the installation labor) at T2 (assuming no change in real costs). The incremental costs would then be calculated as the cost of the new efficient equipment installed now (left column in Figure 2) minus the present value (PV) of the cost that is avoided in the future for the code/standard equipment (right column Figure 2). Figure 2 presents a case in which the DFP is 4 years and, absent the program, the code/standard equipment would have been installed in the fifth year. This calculation differs from the normal/end of life replacement incremental cost in adding the time value of money for spending the money earlier.

Figure 3. Incremental Cost Calculation for Special Circumstance Cases with a DFP of Four Years

Year	PV With Program	PV Without Program
1	Full Cost of High Efficient Equipment	0
2	0	0
3	0	0
4	0	0
5	0	Full Cost of Code/Standard Equipment

The Ratio Approach to the Dual Baseline with the Lookup Tables

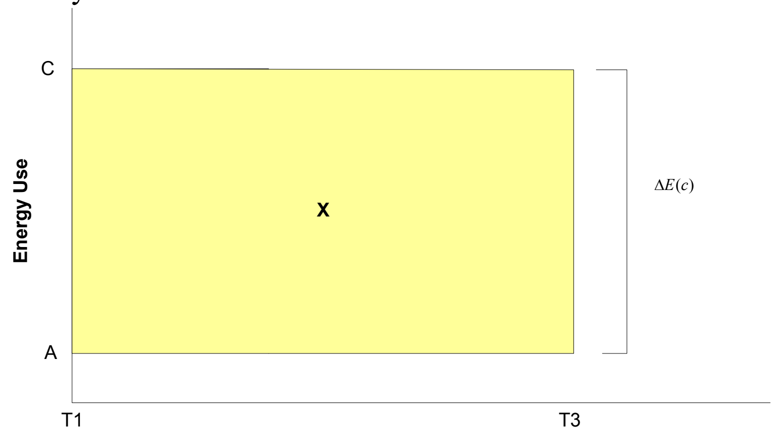
As in Appendix M, this approach focuses on the ratio of incremental energy savings to full energy savings[88] and the ratio of incremental costs to full costs. These ratios, shown at the top of the columns in Tables N-1 through N-2, determine the factors that PAs can use to adjust the savings and cost data. These first two tables require the program administrators to provide their own incremental costs and savings ratios (based on the code/standard equipment). To use these tables, PAs must match the ratios that they have calculated to the nearest corresponding ratios in these tables

To use Table N-1 for benefits, PAs will need to calculate the full annual savings as the annual energy use of the old equipment in place minus the annual energy use of the high efficiency equipment. These full savings are then counted for each year of the EUL as is represented as area *X* in Figure 3. For each year of the EUL (T3 – T1) of the new equipment, the full kWh or therm savings are converted to dollar benefits by multiplying them by the Commission"s avoided costs estimates for that year[89].

[88] The savings values ratios are not area present values but are rather the line segments in Figure 1 on the vertical axis: (B – A) divided by (C – A).

[89] The tables are not territory-specific, but statewide. This is because only the LRAC growth rates matter, not the absolute values, and the growth rates for the various zones are almost identical in the LRACs in use.

Figure 5. Inflated Lifecycle Benefits



$\Delta E(c)$ = C - A
C = Energy use of pre-existing equipment
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T3 = Date on which the new efficient equipment is expected to fail
T3 – T1 = EUL of new efficient equipment

As a preliminary step in using Table N-1, and valid only for that purpose, the PAs will calculate this "inflated lifecycle benefits" for kWh, peak kW, and/or therms as the present value of the stream of full savings benefits for the EUL of the new equipment.[90]

In cases of special circumstance under the ratio approach, it is these inflated lifecycle benefits that must be adjusted using the appropriate *inflated lifecycle benefits adjustment factor*. For a given measure with a given EUL/DFP and ratio of incremental savings to full savings, the inflated lifecycle benefits adjustment factor is the ratio (presented as a percentage) of the present value of the dual baseline lifecycle benefits (X+Y) illustrated in Figure 1 to the present value of the inflated lifecycle benefits illustrated in Figure 3.

Under the Commission requirement of consistent treatment of savings and costs, the full costs[91] must also be adjusted downward. Using research on the costs of standard/code equipment, a PA can calculate the ratios of incremental costs to full costs and obtain the *full cost adjustment factors* from Table N-2. If a PA cannot obtain or chooses not to seek the data necessary to calculate the cost ratios, it can use the ratios and adjustment factors from Tables M-11 through M-19 in Appendix M in cases in which the measures match.

Note that all documentation for PA costs and savings estimates and ratios must be retained for possible Staff or ex post evaluator review.

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[90] Usually, the ratio of incremental kWh savings to full kWh saving would be the same as the ratio of incremental peak kW demand reduction to full peak kW demand reduction, which implies using the same ratio and adjustment factor for both. However, with some measure types, such as cooling, PAs may benefit from calculating different ratios of incremental to full for kWh and kW. A PA can choose to use higher 0.05 increment kW ratios if it can calculate and document them with retention.

[91] Full costs include the capital cost of the new efficient equipment plus installation cost.

Look-Up Tables

Tables N-1 and N-2 have been prepared so that PAs can obtain the Inflated Lifecycle Benefit and the Full Cost adjustment factors. For Inflated Lifecycle Benefits Adjustment Factors, PAs must calculate their own savings ratios. If PAs are able to calculate their own ratios of incremental costs to full costs, they may prefer to use Table N-2. However, as discussed above, in some cases PAs may use the tables in Appendix M to obtain cost ratios and adjustment factors.

For Tables N-1 and N-2, a PA should identify the 0.05 increment ratios that are closest to those it developed. The ratios range from 0.95 to .05 in increments of 0.05, and there are no measure designations.

Note that ratios of 1.0 and 0.0 are not included in the tables. For some measures, the efficiency of the old in place unit is still the common practice or no new standards have been adopted, i.e., the baseline for the full savings and the incremental savings are the same. As a result, the ratio of incremental to full savings is near 1.0, meaning that a PA can claim the full savings for the entire EUL of the new equipment (areas X and Y in Figure 4). Therefore, the lookup tables do not apply. For other measures, the high efficiency equipment subsidized by the program is consistent with current code or standards. For these measures, the incremental savings are zero and thus the ratio of incremental to full savings is 0.0.This means that a PA can claim full savings for only the RUL (area X in Figure 5), after which the high-efficiency replacement would have occurred anyway. Therefore, the lookup tables do not apply.

Figure 4. Efficiency of the Old In Place Unit Is Still the Common Practice Or No New Standards

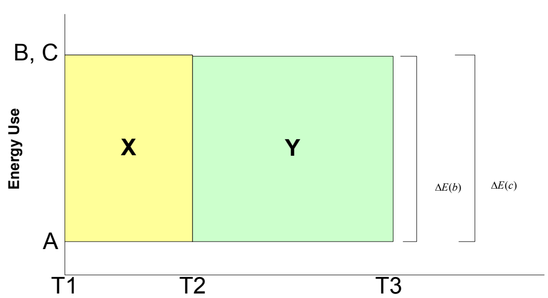
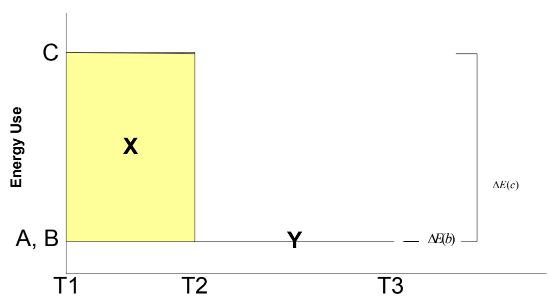


Figure 5. High Efficiency Equipment Subsidized by the Program Is Consistent with Current Code Or Standards



$\Delta E(c)$ = C - A
$\Delta E(b)$ = B - A
C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3= Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected remaining useful life (RUL) of the pre-existing equipment
T3 – T2 = Expected remaining EUL of the new efficient equipment

To use the tables, a PA must gather the following four pieces of information:

- the EUL of the type of equipment,
- the DFP of the old equipment in place (just 25% of the EUL),

- the full savings of the equipment (annual energy use of the old equipment in place minus the annual energy of the high efficiency equipment supported by the program), and
- the full costs (including installation)

Additionally, a PA will need documented estimates, based on equipment minimally compliant with standards/codes or common practice, of incremental savings and costs in order to calculate:

- The ratio of incremental savings to full savings, and
- The ratio of incremental costs to full cost

Again, note that for the costs, PAs can use the Tables in Appendix M where measures match.

Table Organization

Table N-1 contains the Inflated Lifecycle Benefit Adjustment Factors while Table N-2 contains the Full-Cost Adjustment Factors.

In Table N-1, the first row is the ratio of incremental savings to full savings while in Table N-2 the first row is the ratio of incremental to full cost. In both tables, the first two columns identify the EULs and corresponding DFPs:

- 25 Years/6
- 20 Years/5
- 14 to 17 Years/4
- 10 to 13 Years/3

The remaining columns present the respective adjustment factors by ratio of

- Table 1: Incremental savings to full savings
- Table 2: Incremental costs to full costs

Program-Tracking Database Requirements

The program tracking databases contain information for each measure installation which the PAs are required to maintain for the purposes of current reporting and future impact evaluation, the latter requiring many fields not used for current reporting. The following seven additional required variables, as were first required in Appendix M,[92] are being added by Staff through the Evaluation Advisory Group process[93]:

- Type of Installation (TRC Approach)[94] ,

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[92] Note that item #2 above is a correction of item #2 in Section 5 of Appendix M. Furthermore, item #3 is now required in addition to those variables listed in Section 5 of Appendix M. Those using Appendix M should take note of these changes.

[93] Note that for cases of normal replacement and add-on, the variables 2 through 7 should be coded as "n/a" (not applicable).

[94] ER=Early Replacement; NR=Normal Replacement; SC=Special Circumstance; AO=Add On. Add on refers to adding something that replaces nothing. Examples include adding controls to a boiler that had

- The Full Savings (kWh or therms),
- If electric, the on-peak demand reductions associated with the Full Savings,
- The *Adjusted Full Cost* (full cost multiplied by the full-cost adjustment factor),
- The Ratio of Incremental Savings to Full Savings,
- The Ratio of Incremental Costs to Full Costs, and
- The *Adjusted EUL* (discussed below).

The Adjusted EUL is defined as that period of years over which the present value benefits of the full savings would approximate the present value dollar benefits of the underlying dual baseline. Figure 6 shows the Adjusted EUL Tx, reduced from the actual EUL T3 such that the lifecycle savings over the period Tx – T1 approximates the lifecycle savings over the period T3 – T1 in Figure 1 (repeated from above). The longer the DFP is, the longer the adjusted EUL, owing to more years at full savings.

Figure 1. Lifecycle Savings: Dual Baseline

Figure 6: Lifecycle Savings: Approximation to Dual Baseline

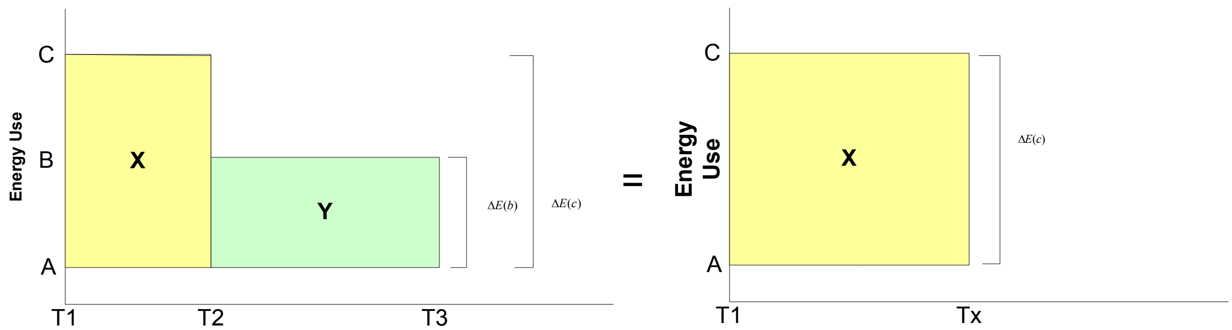

Table N-3 presents the adjusted EULs in years for each possible ratio (in 0.05 increments). In Table N-3, the first row is the incremental to full savings ratio and the first two columns identify the EULs and corresponding DFPs. The adjusted EUL is not used for TRC screening, but only for the program‟s tracking database. Table N-3 is organized in the same way as the Table N-1. Note that Tables N-1 through N-3 are also available in Excel.

Example

Consider the following example. Suppose a PA finds in place equipment with an EUL of 17 years whose age is determined to be 22 years. The five years over the EUL is greater than 25% of the EUL (17/4 = 4.25 which rounds to 4, which is also the DFP). The equipment is eligible for special circumstance treatment if it also meets criteria #3 and #4. The PA has determined that the ratio of incremental savings to full savings is 0.65 and the ratio of incremental costs to full costs is 0.40. To find the Inflated Lifecycle Benefits Adjustment Factors, the Full Cost Adjustment Factors, and the Adjusted EUL for this measure, the PA must go to Table N-1 and identify the row for measures with an EUL of 17 years and a DFP of 4 years. Next, they must identify the column with an incremental savings to full savings ratio of 0.65. The value in the

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none, or adding insulation where there was none or some. Add-on measures are modeled at full costs and full savings for the length of their EULs. The full savings are reported toward first-year goals.

intersection of this row and this column is 0.75, which is the Inflated Lifecycle Benefits Adjustment Factor. Using Table N-3, the same procedure would be followed to obtain the Adjusted EUL of 10 years.

To find the Full Cost Adjustment Factor, the PA would go to Table N-2, find the row with a 4-year DFP and the column with a ratio of 0.40. The value in the cell is 0.52, which is the Full Cost Adjustment Factor. As discussed above, in some cases PAs may use the tables in Appendix M to obtain cost ratios and adjustment factors.

The next step is to multiply the inflated benefits by the benefits factor and the full costs by the costs factor. For Total Resources Cost (TRC) analysis, ratio the two products, benefits/costs. For first year savings to report against approved program goals, for special circumstances replacements PAs would use the full savings, the first baseline of the existing equipment versus the high efficiency program measure.

Table N-1. Inflated Lifecycle Benefit Adjustment Factors for PA-Supplied Ratios of Incremental Savings to Full Savings, by DFP, for kWh, kW, and Therm Savings

	DFP	Median Ratio of Incremental Savings to Full Savings																		
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
		Inflated Lifecycle Benefit Adjustment Factors																		
25 Year EUL	6	42%	42%	47%	52%	52%	56%	60%	64%	64%	68%	71%	75%	78%	81%	84%	86%	91%	94%	96%
20 Year EUL	5	42%	42%	47%	47%	53%	53%	58%	63%	63%	67%	72%	76%	76%	80%	84%	87%	91%	94%	97%
17 to 14 Year EUL	4	35%	43%	43%	50%	50%	56%	56%	63%	63%	69%	69%	75%	75%	80%	86%	86%	91%	95%	95%
13 to 10 EUL	3	32%	41%	41%	41%	50%	50%	58%	58%	66%	66%	66%	73%	73%	81%	81%	87%	87%	94%	94%

Table N-2. Full Cost Adjustment Factors for PA-Supplied Ratios of Incremental Cost to Full Cost, by DFP

	DFP	Median Ratio of Incremental Cost to Full Cost																		
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
		Full Cost Adjustment Factors																		
25 Year EUL	6	31%	35%	38%	42%	46%	49%	53%	56%	60%	64%	67%	71%	75%	78%	82%	85%	89%	93%	96%
20 Year EUL	5	27%	31%	35%	39%	43%	46%	50%	54%	58%	62%	66%	69%	73%	77%	81%	85%	89%	92%	96%
17 to 14 Year EUL	4	23%	27%	31%	35%	39%	43%	48%	52%	56%	60%	64%	68%	72%	76%	80%	84%	88%	92%	96%
13 to 10 EUL	3	19%	23%	28%	32%	36%	40%	45%	49%	53%	57%	62%	66%	70%	74%	79%	83%	87%	91%	96%

Table N-3. Adjusted EULs, by DFP

	DFP	Median Ratio of Incremental Savings to Full Savings																		
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
		Adjusted EULs in Years																		
25 Year EUL	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	16	16
20 Year EUL	5	6	6	7	7	8	8	9	10	10	11	12	13	13	14	15	16	17	18	19
17 to 14 Year EUL	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	12	12	13	14	14
13 to 10 EUL	3	3	4	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	11

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0	10/15/2010

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APPENDIX O

COMMERCIAL AND INDUSTRIAL LIGHTING POLICY

INTRODUCTION

On January 12, 2011 Staff issued a SAPA Notice, in part on proposals to implement directives in the Commission"s October 18, 2010 order in Case 07-M-0548 regarding benefit/cost analysis for Special Circumstance customers in Energy Efficiency Portfolio Standard (EEPS) programs.[95] In its 2/28/11 comments, National Grid sought clarification regarding: whether field staff must determine the age of lighting fixtures in place and how to treat lighting replacement where the age of the fixture in place is past its prescribed effective useful life (EUL). With regard to these lighting issues, the Commission in its July 18, 2011 order in the EEPS proceeding directed[96] "the Implementation Advisory Group to attempt to resolve the issues of determining the age of lighting equipment and the correct approach for valuing savings from lighting replacements[97] under the mechanism we provided for modifying the Consolidated Technical Manual [CTM] in our June 20, 2011 Order in this proceeding."[98]

Regarding commercial and industrial lighting issues,[99] the technical manual, effective 1/1/11 [*as modified September 2012]*, states: "The baseline condition is assumed to be the existing *[and operational]* lighting fixture in *[all applications other than new construction or extensive renovations which trigger the building code*]." This makes the savings baseline and costs for TRC analysis independent of the age of the operational fixture. This approach reflects the frequent impracticality of determining the age of lighting fixtures

Absent this provision, replacement of fixtures in place which are either (1) irreparable (unusable and not economic to repair) or, (2) operating and not demonstrably younger than their EUL (in short, broken or past EUL) would be treated as normal/end of life replacement: modeled with incremental costs and with incremental savings for the full EUL of the new measure, including for first year scorecard reporting.[100] Fixtures in place in working order and demonstrably aged below their EUL would get early replacement treatment which, for most non-lighting measures, would mean dual baseline treatment per Appendix M. Appendix M, however, excludes lighting from such treatment.[101] Therefore, the conventional early replacement modeling of full costs and full savings would still apply, with the full savings against the old fixture in place modeled for the full EUL of the new equipment and reported as first year scorecard savings.

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95 SAPA 07-M-0548SP30 - Proceeding on Motion of the Commission Regarding an Energy Efficiency Portfolio Standard.
96 Order Approving Modifications to the Technical Manual, pp. 16-17.
97 Savings are related to the type of lamp used in the fixture.
98 New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, October 15, 2010, p. 109, www.dps.ny.gov/Tech ManualNYRevised10-15-10.pdf
99 C&I lighting includes multi-family building common areas for the purposes of this paper.
100 Incremental means the costs and consumption of the high efficiency model promoted by the program minus the costs and consumption of the standard efficiency level alternative – Federal minimum appliance standards, State building codes or, in the absence of codes and standards, the common practice.
101 Appendix M, posted with Technical Manual, see footnote #5, p. 10.

In compliance with instructions stated in the July 18, 2011 Order, this appendix prescribes principles for C&I lighting replacements, both replacements of operational fixtures and irreparable fixtures, addressing:

- Replacements for which incentive funding is precluded, as a practical matter of presumptive TRC failure by definition,
- Inputs for TRC ratio calculations,
- Age determination requirements (none), and
- Values for reporting as first year annualized savings against targets approved in orders (the same as the first year savings modeled in the TRC analysis).

THE OVERALL PRINCIPLES

If a lighting fixture of any age is operational, replacement is early replacement. The full savings against the fixture in place[102], will be reported as first year savings and modeled for the full EUL of the replacement measure in TRC screening. Costs will be full costs, the total costs of the replacement, as is usual for early replacement analysis outside Appendix M.[103]

For irreparable lighting fixtures, normal/end of life rules apply: incremental savings and costs between the common practice and the high efficiency measures promoted by EEPS are used for TRC analysis; incremental savings are used for first year scorecard savings; and no age determination is required.

DISCUSSION BY TYPE OF EQUIPMENT REPLACED

The lighting upgrades considered here are; screw-in incandescent fixtures (which will evolve toward use of halogen lamps)[104] replaced with CFL or LED fixtures. Linear fluorescent T12 or standard T8 replaced with Super T8s, T5s or LEDs.[105] The fixtures in place may be either in good working order (early replacement) or irreparable (normal replacement).

Baselines: Screw-In Fixtures

Screw-in fixtures are expected to continue to accommodate the least efficient lamp types which still meet the national lighting standards established under the Energy Independence and Security Act of 2007 (EISA).Therefore, the baseline choice for early or normal replacement with any pin-based fixtures remains screw-in fixtures: either to keep a working fixture in place or to replace an irreparable one with a new screw-in fixture. Once the EISA standard is phased-in for a particular lamp size the least efficient lamp technology meeting the standard

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[102] The full savings differs from incremental savings in subtracting the consumption of the fixture supported by the program from the consumption of the fixture in place, not from the consumption of the current common alternative.

[103] If passing the TRC, however, is a concern, PAs may choose to document an age past the EUL to be able to model the incremental costs used re: normal replacement as opposed to the full costs usual for early replacement.

[104] Halogen lamps consume approximately 72% as much as incandescent lamps. Whereas the TRM reports a delta of watts consumption of 2.53 between CFLs and incandescent lamps, the delta would be approximately 1.55 for CFLs against halogen lamps. This means that 1.55 times the CFL wattage is the savings delta against a halogen lamp.

[105] Speaking only of the types whose replacement are usual subjects of EEPS programs, thus not including high intensity discharge (HID) fixtures, metal halide, high pressure sodium, mercury vapor, *or CFLs or LEDs yet*. Perhaps at some point it will be cost effective to replace CFLs with LED lamps.

would normally be considered the baseline. Incandescent lamps, however, are expected to remain in inventories for sale and are reportedly being stockpiled. A screw-in fixture can house, for baseline consumption relative to CFLs, either incandescent or halogen lamps. Therefore, baselines will be based upon deemed years, for each wattage range, in which installation of the new common practice technology, halogen lamps, is more likely than installation of stockpiled incandescent lamps.[106] Until reconsideration (based on studies in progress and program experience) in March 2015, incandescent lamps will remain the baseline.

For fixtures compatible with incandescent and halogen lamps, TRC analysis of a measure or project may be occurring before the deemed switch year or after it. Analysis done before the estimated switch year will entail two baselines of consumption during the EUL of the screw-in alternative to CFL.[107] The first baseline will be incandescent lamp consumption until the beginning of the deemed switch year,[108] the second baseline being halogen lamp consumption. In future TRC analysis after the deemed switch dates, the baseline for incremental savings will be halogen lamps against CFLs throughout.

Baselines: Linear Fluorescent Fixtures

For early replacement of an operational T12 fixture, the baseline relative to super T8s is simply the consumption of the T12 lamp. For normal replacement of an irreparable T12 fixture, the baseline, until reconsideration (based on studies in progress and program experience) in March 2015, is the consumption of a T12. At some point, customers will no longer be installing relatively inefficient T12 fixtures in significant numbers as lamp availability decreases[109] and therefore standard T8s will be the common practice and thus the suitable linear fluorescent baseline for consideration of appropriate super T8s and T5s.

Eligibility for Rebates

The next issue is potential cost-effectiveness and thus measures‟ eligibility for rebates. Incentives for CFL (and potentially for LED lamp) pin fixtures, as needed and if cost- effective, may continue to be appropriate for some years to come.[110] Incandescent/halogen fixtures may remain in use indefinitely, with halogens being less expensive upfront as well as more familiar looking than CFLs or LED lamps. Replacement of screw-in fixtures with new screw-in fixtures may continue, and thus incentives for replacement with higher efficiency technologies make sense.

Turning to rebate-eligibility of linear fluorescent fixtures, since installation of T12 fixtures will be unlikely at some point and replacement of a standard T8 fixture with a standard T8 fixture would yield no savings. At that point, savings will exist and cost-effective incentives will be

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[106] While in reality the technology mixes will shift gradually, the baselines as executed here will require selection of the year in which the probable majority choice will switch.
[107] Screw-in LEDs are unlikely in the C&I context in which quality concerns require LED fixtures.
[108] While incandescent lamps installed before the switch year may remain in use during it, this would probably be for a short time given the usual heavy C&I usage. Additionally, fractional year modeling is not practical.
[109] This will not happen often enough to justify ratepayer subsidy of all replacements to avoid the occasional instance. Retrogression from T8 to T12 is particularly unlikely.
[110] This is also applicable for screw-in CFLs for incandescent/halogen fixtures.

payable only for installation of super T8s (or T5s) in watts-saving configurations. Super T8s produce more lumens per watt and have improved color rendering and a longer rated life, but since ratepayers should not pay for extra lumens, incentives should be paid only for projects which reduce the overall wattage of fixtures relative to standard T8s.

COSTS TO BE MODELED

The last issue is costs to be modeled in TRC screening. For early replacement of operational, screw-in incandescent/halogen fixtures, the TRC screening would as usual include the full *costs* of the replacement, additionally owing to the indefinite remaining life of the fixture in place, and to the continued availability of inexpensive screw-in fixtures usable for halogen. Since most equipment replaced will be in working order, the full-costs case will be the most common, but with incremental costs for normal replacement of irreparable fixtures.

Turning to costs to be modeled for linear fluorescent fixtures, operational standard T8s can remain in place for some years, and therefore full costs for early replacement are fully appropriate. If age past the EUL is documented, however, PAs may model incremental costs for normal replacement. Also as a case of normal replacement, since irreparable standard T8 fixtures can be replaced with like, the modeling of incremental costs for super T8 fixtures is justified.

Record of Revision

Record of Revision Number	Issue Date
0	10/15/2010
3-3-1	3/14/2013

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APPENDIX P

EFFECTIVE USEFUL LIFE (EUL)

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Appliance	Clothes Washer	Single-family	11	DEER
		Multi-family	14	NWPPC
	Dehumidifier	Residential	12	US EPA[111]
	Dishwasher	Residential	11	DEER
	Refrigerator Replacement	Residential	17	NYS DPS
Appliance Recycling	Air Conditioner - Room (RAC), Recycling	Residential	3	DEER[112]
	Refrigerator Recycling	Residential	5	DEER[113]
	Freezer Recycling	Residential	4[114]	DEER[115]
Building Shell	Air Leakage sealing	Residential	15	GDS[116]
	Hot Water Pipe Insulation	Residential	13 – Electric 11 – Natural Gas	DEER
	Opaque Shell Insulation	Residential	30	Energy Trust of Oregon and CEC[117]
	Window & Through the wall AC cover and Gap Sealer	Residential	5	See note below[118]
	Windows Replacement	Residential	20	DEER
Domestic Hot Water	Domestic Hot Water Tank Blanket	Residential	10	NYSERDA[119]
	Heat Pump Water Heater – Air Source (HPWH)[120]	Residential	10	DEER[121]
	Indirect Water Heater	Residential	13	DEER[122]
	Storage Tank Water Heater	Residential	15	DEER
	Instantaneous Water Heater	Residential	20	DEER

[111] ENERGY STAR Dehumidifier Calculator www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls
[112] IBID
[113] DEER 2008 RUL assumptions, based on 1/3 of DEER EUL
[114] The hypothetical remaining years of use in the absence of removal of the appliance by the program
[115] DEER 2008 RUL assumptions, based on 1/3 of DEER
[116] IBID
[117] http://energytrust.org/library/reports/resource_assesment/gasrptfinal_ss103103.pdf
[118] At least one manufactures warranty period. www.gss-ee.com/products.html
[119] NYSERDA Energy Smart Program Deemed Savings Database. Rev 9 – 062006
[120] Electric heat pump used for service hot water heating
[121] Effective Useful Life tables to be used by California IOUs for 2009-2011 program cycle planning from the California DEER website: www.deerurces.com
[122] Based on EUL of unfired (electric) water heater tank from DEER

Category	Single and Multi-family Residential Measures	Sector	EUL (years)	Source
Domestic Hot Water - Control	Faucet- Low flow Aerator	Residential	10	DEER
	Shower Restriction Valve	Residential	9	UPC[123]
	Shower Head – Low flow	Residential	10	DEER
Heating, Ventilation and Air Conditioning (HVAC)	Air Conditioner and Heat pump – Refrigerant charge correction	Residential	10	DEER
	Air Conditioner and Heat pump – Right sizing	Residential	15	DEER[124]
	Air Conditioner, Central (CAC)	Residential	15	DEER[125]
	Air Conditioner – Room (RAC)	Residential	9	DEER
	Boiler	Residential	25	Efficiency VT[126]
	Circulator – with Electronically Commuted Motor (ECM) for Hydronic distribution	Residential	15	DEER[127]
	Duct sealing and Insulation	Residential	18	DEER
	Fan Motor – with Electronically Commuted Motor (ECM) for Furnace Distribution	Residential	15	DEER
	Furnace	Residential	20	DEER
	Furnace Tune-up	Residential	5	See note below[128]
	Heat Pump - Air Source (ASHP)	Residential	15	DEER[129]
	Heat Pump – Ground Source (GSHP)	Residential	20	US DOE
HVAC - Control	Outdoor Reset Control for Hydronic Boiler	Residential	15	ACEEE[130]
	Thermostat – Programmable Setback	Residential	11	DEER
	Thermostatic Radiator Valve	Multi-family	12	NYS DPS

[123] UPC certification under the International Association of Plumbing and Mechanical Officials standard IGC 244-2007a. A standard that includes a lifecycle test consisting of 10,000 cycles without fail. 10,000 cycles is the equivalent of three users showering daily for more than nine years.
[124]Savings assumed to persist over EUL of air conditioner or heat pump
[125] Effective Useful Life tables to be used by California IOUs for 2009-2011 program cycle planning. From the California DEER website: www.deeresidentialsources.com
[126] Efficiency Vermont Technical Reference Manual, ver. 4
[127] Based on DEER value for furnace fans
[128] Reduced from DEER value of 10 years
[129] Effective Useful Life tables to be used by California IOUs for 2009-2011 program cycle planning. From the California DEER website: www.deeresidentialsources.com
[130] Potential for Energy Efficiency, Demand Response and Onsite Solar Energy in Pennsylvania, ACEEE report number E093. April 2009

Category	Single and Multi-family Residential Measures		Sector	EUL (years)	Source
Lighting	Compact Fluorescent Lamp (CFL)		Residential	Coupon – 5	GDS
				Direct Install – 7	GDS
				Markdown - 7	GDS
			Multi-family Common area	9,000 hrs/ annual operating hrs	See note below[131]
	Light Fixture	Linear Fluorescent	Residential / Multi-family Common area	70,000 hrs / annual operating hrs, or 20 yrs (whichever is less)	DEER[132]
		CFL	Residential / Multi-family Common area	22,000 hrs / annual operating hrs, or 20 yrs (whichever is less)	See note below[133]
Lighting Control	Stairwell Dimming Light Fixture/Sensor		Multi-family	12	GDS[134]

[131] Multi-family common areas tend to have longer run hours than dwelling units. Default value from C&I lighting table is 7,665 hours per year
[132] Basis value 70,000 hours, capped at 20 years, is common given redecoration patterns
[133] Basis value 22,000 hour ballast life per US EPA. Capped at 20 years as above (2.5 hours per day average lamp operation)
[134] GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group

COMMERCIAL AND INDUSTRIAL MEASURES

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Agricultural	Engine Block Heater Timer	C&I	8	See note below[135]
Appliance	Electric Cooking Equipment (Oven, Fryer, Steamer)	C&I	12	DEER
	Gas Fired Cooking Equipment (Oven, Griddle, Fryer, Steamer)	C&I	12	DEER
	Refrigerator Replacement	C&I	12	DEER
Appliance Control	Vending Machine/ Novelty Cooler Time clock	C&I	5	DEER
Building Shell	Cool Roof	C&I	15	DEER
	Hot Water Pipe Insulation	C&I	13 – Electric 11 – Natural Gas	DEER
	Window - Film	C&I	10	DEER
	Window - Glazing	C&I	20	DEER
	Opaque Shell Insulation	C&I	30	Energy Trust and CEC[136]
Compressed Air	Air Compressor Upgrade	C&I	15	Ohio TRM[137]
	Refrigerated Air Dryer	C&I	15	Ohio TRM
	Engineered Air Nozzle	C&I	15	PA Consulting for Wisconsin PSC[138]
	No Air Loss Water Drain	C&I	15	Ohio TRM[139]
Domestic Hot Water (DHW)	Domestic Hot Water Tank Blanket	C&I	7	DEER
	Indirect Water Heater	C&I	15	DEER[140]
	Storage Tank Water Heater	C&I	15	DEER
	Tankless Water Heater	C&I	20	DEER
	Heat Pump Water Heater - Air Source (HPWH)	C&I	10	DEER
DHW - Control	Faucet- Low Flow Aerator	C&I	10	DEER
	Showerhead – Low Flow	C&I	10	DEER
	Pre-rinse Spray Valve	C&I	5	GDS

135 Based on EUL‟s for similar control technology

136 Energy Trust uses 30 years for commercial applications. http://energytrust.org/library/reports/Residentialource_assesment/gasrptfinal_ss103103.pdf. CEC uses 30 years for insulation in Title 24 analysis

137 Ohio Technical Reference Manual (TRM). Based on a review of TRM assumptions from Vermont, New Hampshire, Massachusetts, and Wisconsin. Estimates range from 10 to 15 years. www.OhioTRM.org

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

139 EUL for this measure not available. Default to air compressor upgrade EUL from Ohio TRM. www.OhioTRM.org

140 EUL for commercial central water heater used

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Heating, Ventilation and Air Conditioning (HVAC)				
	Air Conditioner and Heat Pump – Refrigerant Charge Correction	C&I	10	DEER
	Air Conditioner – Package (PTAC)	C&I	15	DEER
	Chiller – Air & Water cooled	C&I	20	DEER
	Chiller – Cooling Tower	C&I	15	DEER
	Combination Boiler and Water Heater	C&I	20	DEER[141]
	Condensing Gas-Fired Unit Heater for space heating	C&I	18	Ecotope[142]
	Duct Sealing and Insulation	C&I	18	DEER
	ECM Motors on HVAC Equipment, including fan powered terminal boxes, fan coils, and HVAC supply fans.	C&I	15	DEER[143]
	Economizer – Air Side, w/dual enthalpy control	C&I	10	DEER
	Furnace and Boiler	C&I	20	DEER
	Heat Pump – Air Source, Package (PTHP)	C&I	15	DEER
	Infrared Gas Space Heater	C&I	17	GDS
HVAC - Control	Thermostat – Programmable Setback	C&I	11	DEER
	Boiler Reset Control	C&I	15	See note below[144]
	Demand Controlled Ventilation	C&I	10	DEER
	Energy Management System	C&I	15	DEER
	Hotel Occupancy Sensors for PTAC and HP Units	C&I	8	DEER[145]
	Steam Traps Repair/Replace	C&I	6	DEER

[141] Based on DEER value for high efficiency boiler
[142] Ecotope Natural Gas Efficiency and Conservation Measure Resource Assessment (2003)
[143] DEER value for HVAC fan motors
[144] Set to 15 years, consistent with Energy Management System (EMS) value in DEER
[145] DEER value for occupancy sensor controls. Hardwired (not battery powered) controls only

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	CFL Lamp	C&I	9,000 hours /annual operating hours	See note below[146]
	CFL Light Fixture	C&I	12	DEER
	Interior & Exterior, including linear fluorescent	C&I	70,000 hours /annual operating hours or 15 years, whichever is less	DEER[147]
	Interior Dry Transformers	C&I	25	See note below[148]
	LEDs Fixtures and Screw-In Lamps (other than refrigerated case)	C&I	35,000 or 50,000 hours	DLC[149]
			35,000 hours	Energy Star[150]
			15,000 hours for decorative, or 25,000 for all other	Energy Star[151]
			25,000 hours	Uncertified
	Refrigerated Case LED	C&I	6	NW RTF[152]
Lighting - Control	Interior & Exterior Lighting Control	C&I	8	DEER
	Stairwell Dimming Light Fixture/Sensor	C&I	12	GDS[153]
	Plug-Load Occupancy Sensor	C&I	8	DEER[154]
Motors and drives	Motor replacement (with HE motor)	C&I	15	DEER
	Variable Frequency Drive – Fan and Pump	C&I	15	DEER

[146] Based on reported annual operating hours; default value by space type in the technical manual (pp. 109-110)
[147] Basis Value 70,000 hours, capped at 15 years to reflect C&I redecoration and business type change patterns
[148] 25 yrs for new transformers is conservative estimate based on literature review: DOE assumes typical service lifespan of 32 yrs; ASHRAE lists typical service life of 30 yrs
[149] Placed on the Qualified Products List by the Design Light Consortium (DLC) 35,000 or 50,000 hours, according to the appropriate Application Category as specified in the DLC"s Product Qualification Criteria, Technical Requirement Table version 2.0 or higher
[150] Placed on the Qualified Fixture List by Energy Star, according to the appropriate luminaire classification as specified in the Energy Star Program requirements for Luminaires, version 1.2. Divided by estimated annual use, but capped at 15 years regardless (consistent with C&I redecoration and business type change patterns
[151] Placed on the Qualified Lamp Products List by Energy Star, according to the appropriate lamp classifications as specified in the Energy Star Program Requirements for Integral LED Lamps, version 1.4. Divided by estimated annual use, but capped at 15 years regardless (consistent with C&I redecoration and business type change patterns)
[152] Northwest Regional Technical Forum (RTF) value
[153] GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group
[154] DEER value for lighting occupancy sensors

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Refrigeration	Air Cooled Refrigeration Condenser	C&I	15	DEER
	Equipment (Condensers, Compressors, and Sub-cooling)	C&I	15	DEER
	Fan Motor – Refrigerated Case and Walk-In Cooler, with ECM	C&I	15	DEER
	Refrigerated Case Night Cover	C&I	5	DEER
	Auto/Fast Close Door Walk-In Coolers/Freezers	C&I	8	DEER
	Strip Curtains and Door Gaskets for Reach-In or Walk-In Coolers/Freezers	C&I	4	DEER
Refrigeration - Control	Anti-Condensation Heater control	C&I	12	DEER
	Evaporator Fan Control	C&I	16	DEER
	Condenser Pressure and Temperature Controls	C&I	15	DEER

Record of Revision

Record of Revision Number	Issue Date
EUL‟s originally listed in July 18, 2011 Order	7/18/2011
Additional EUL‟s posted on web site	Subsequent to 7/18/2011 Order
7-13-28	7/31/2013
6-14-1	6/19/2014
6-14-2	6/19/2014

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FORMS

TYPICAL MEASURE HEADINGS

Measure Name ____

Measure Description ____

Method for Calculating Annual Energy and Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = units \times (savings\ equation)$$

Peak Coincident Demand Savings

$$\Delta kW = units \times (savings\ equation) \times CF$$

Annual Gas Energy Savings

$$\Delta therms = units \times (savings\ equation)$$

WHERE:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
Δtherms	= Annual gas energy savings
units	= Number of measures installed under the program
CF	= Coincidence factor

Summary of Variables and Data Sources

Variable	Value	Notes

Coincidence Factor (CF)

The recommended value for the coincidence factor is ________

Baseline Efficiencies from which Savings are Calculated

____

Compliance Efficiency from which Incentives are Calculated

____

Operating Hours

____

Effective Useful Life (EUL)

Years: ___________________

Source: ____

Ancillary Fossil Fuel Savings Impacts

____

Ancillary Electric Savings Impacts

____

References

1. ____

Record of Revision

Record of Revision Number	Issue Date
(example) 8-26-2014	(example) 8/29/2014

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GLOSSARY

ABBREVIATIONS, ACRONYMS, AND EQUATION VARIABLES	
$\overline{COP}$	Average coefficient of performance
η	Energy efficiency (0 -100%)
$\overline{\eta}$	Average energy efficiency (0 -100%)
$\overline{\Delta T}$	Average temperature difference
$\overline{EER}$	Seasonal average energy efficiency ratio over the cooling season BTU/watt-hour, (used for a particular climate/building)
Δ kW	Peak coincident demand electric savings
Δ kWh	Annual electric energy savings
Δ Q	Heat difference/loss
Δ T	Temperature difference
Δ therms	Annual gas energy savings
Δ	Change, difference, or savings
A	Amperage
AC	Air conditioning
ACCA	Air Conditioning Contractors of America
ACEEE	American Council for an Energy-Efficient Economy
ACH	Air change per hour
AFUE	Annual fuel utilization efficiency, seasonal energy efficiency for fuel heating equipment
AHAM	Association of Home Appliance Manufacturers
AHRI	Air Conditioning Heating and Refrigeration Institute
AHU	Air handling unit
AIA	American Institute of Architects
ANSI	American National Standards Institute
APU	Auxiliary power unit
area	Extent of space or surface
ARI	Air-Conditioning & Refrigeration Institute
ARRA	American Recovery and Reinvestment Act of 2009
ASHP	Air source heat pump
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
BLDC	Brushless DC electric motor
BTU	British Thermal Unit
BTUh	British Thermal Units per hour
CAC	Central air conditioner
CAV	Constant air volume
CBECS	Commercial Buildings Energy Consumption Survey
CDD	Cooling degree days
CEC	State of California Energy Commission
CF	Coincidence factor
CFL	Compact fluorescent lamp

CFM	Cubic foot per minute
CHW	Chilled water
CHWP	Chilled water pump
CLH	Cooling load hours
CMU	Concrete masonry
COP	Coefficient of performance, ratio of output energy/input energy
CV	Constant volume
CW	Condenser water
CWP	Condenser water pump
D	Demand
DC	Direct current
DCV	Demand controlled ventilation
DEER	Database for Energy Efficiency Resources, California
DF	Demand diversity factor
DFP	Default functional period
DHW	Domestic hot water
DLC	DesignLights Consortium®
DOAS	Dedicated outdoor air system
DOE 2.2	US DOE building energy simulation, and cost calculation tool
DPS	Department of Public Service, New York State
DSF	Demand savings factor
DX	Direct expansion
ECCC NYC	Energy Conservation Construction Code of New York City
ECCC NYS	Energy Conservation Construction Code of New York State
EC	Electronically commutated
Econ	Economizer
Ecotope	Ecotope Consulting, Redlands, CA
EEPS	Energy Efficiency Portfolio Standard
EER	Energy efficiency ratio under peak conditions
EF	Energy factor
Eff	Efficiency
Eff_c	Combustion efficiency
Efficiency Vermont	State of Vermont Energy and Efficiency Initiatives
Eff_t	Thermal efficiency
EFLH	Equivalent full-load hours
EIA	Energy Information Administration, US
EISA	Energy Independence and Security Act (EISA) of 2007
ENERGY STAR®	U.S. Environmental Protection Agency voluntary program
Energy Trust	Energy Trust of Oregon, Inc.
EPA	Environmental Protection Agency (EPA), US
EPACT	Energy Policy and Conservation Act of 2005
EPDM	Ethylene propylene diene monomer roofing membrane

ERV	Energy recovery ventilation
ESF	Energy savings factor
EUL	Effective useful life
$Evap_{fan}$	Evaporator fan
Exh	Exhaust
F	Savings factor
FEMP	Federal Energy Management Program
FLH	Full-load hours
FLOW	Nozzle flow
FPFC	Four pipe fan coil
ft^2	Square foot
GDS	GDS Associates, Marietta, GA
Glazing area	Aperture area of glazing
GPD	Gallons per day
GSHP	Ground source heat pump
HDD	Heating degree day
HID	High intensity discharge lamp
hp	Horsepower
HP	High performance
hrs	Hours
HSPF	Heating seasonal performance factor, total heating output (supply heat) in BTU (including electric heat) during the heating season / total electric energy heat pump consumed (in watt/hr)
ht	Height
HVAC	Heating, ventilation, and air conditioning
$HVAC_c$	HVAC interaction factor for annual electric energy consumption
$HVAC_d$	HVAC interaction factor at utility summer peak hour
$HVAC_g$	HVAC interaction factor for annual natural gas consumption
HW	Hot water
IECC	International Energy Conservation Code
IEER	Integrated energy efficiency ratio
IESNA	Illuminating engineering Society of North America
IPLV	Integrated Part-Load Value, a performance characteristic, typically of a chiller capable of capacity modulation.
k	Thermal conductivity
$KBTUh_{input}$	Annual gas input rating
$kBTUh_{output}$	Annual gas output rating
kW	Kilowatt
L	Length
LBNL	Lawrence Berkeley National Laboratory
leakage	Estimate of percent of units not installed in service territory
LED	Light emitting diode
LEED	Leadership in Energy and Environmental Design
LPD	Lighting power density

LRAC	Long-run avoided cost
LSAF	Load shape adjustment factor
MEC	Metropolitan Energy Center
NAECA	National Appliance Energy Conservation Act of 1987
NBI	New Buildings Institute
NEA	National Energy Alliances
NEAT	National Energy Audit Tool
NEMA	National Electrical Manufacturers Association
NREL	National Renewable Energy Laboratory
NRM	National Resource Management
NSTAR	Operating company of Northeast utilities
NWPPC	Northwest Power Planning Council
NWRTF	Northwest Regional Technical Forum
NY DPS	New York State Department of Public Service
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
^{o}F	Degrees Fahrenheit
OSA	Outdoor supply air
PA Consulting	PA Consulting Group
PF	Power factor
Phase	Number of phases in a motor (1 or 3) Single Phase is a type of motor with low horsepower that operates on 120 or 240 volts, often used in residential appliances. Three phase is a motor with a continuous series of three overlapping AC cycles offset by 120 degrees. Three-phase is typically used in commercial applications.
PLR	Power loss reduction
PNNL	Pacific Northwest National Laboratory
PSC	Public Service Commission, New York State
PSF	Proper sizing factor
PSZ	Packaged single zone
PTAC	Package terminal air conditioner
PTHP	Packaged terminal heat pump
Q	Heat
$Q_{reduced}$	Reduced heat
Q_{reject}	Total heat rejection
r	Radius
RA	Return air
RAC	Room air conditioner
RE	Recovery efficiency
RECS	Residential Energy Consumption Survey
RESNET	Residential Energy Services Network
RH	Reduced heat
RLF	Rated load factor
RPM	Revolutions per minute

R-value	A measure of thermal resistance particular to each material
S	Savings
SAPA	State Administrative Procedure Act
SBC	System Benefit Charge
SCFM	Standard cubic feet per minute @ 68 ^{o}F and 14.7 psi standard condition
SEER	Seasonal average energy efficiency ratio over the cooling season, BTU/watt-hour, (used for average U.S. location/region)
sf	Square foot
SHGC	Solar heat gain coefficient
SL	Standby heat loss
Staff	NYS Department of Public Service Staff
T	Temperature
TAF	Temperature adjustment factor
TEFC	Totally enclosed fan cooled
th	Thickness
therm	Unit of heat
THR	Total heat rejection
TMY	Typical meteorological year
tons	Tons of air conditioning
tons/unit	Tons of air conditioning per unit, based on nameplate data
TRC	Total Resources Cost
TRM	Technical Resource Manual
UA	Overall heat loss coefficient (BTU/hr-°F)
unit	Measure
units	Number of measures installed under the program
UPC	Uniform Plumbing Code under the International Association of Plumbing and Mechanical Officials
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
U-value	Measure of heat loss in a building element/overall heat transfer co-efficient
V	Volt
v	Volume
VAV	Variable air volume
VSD	Variable speed drive
W	Watts
w	Width
Wisconsin PSC	State of Wisconsin Public Service Commission

Equation Conversion Factors	
0.000584	Conversion factor used in DOE test procedure
0.00132	Electric efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.
0.0019	Natural gas efficient storage type water heater replacing standard storage tank water heater. NAECA referenced as function of storage volume.
0.285	Conversion factor, one kW equals 0.285388 ton
0.293	Conversion factor, one BTU/h equals 0.293071 watt
0.67	Natural gas water heater Energy Factor
0.746	Conversion factor (kW/hp), 0.7456999 watts equals one electric horsepower
0.97	Electric resistance water heater Energy Factor
1.08	Specific heat of air × density of inlet air @ 70°F × 60 min/hr
1.6	Typical refrigeration system kW/ton
3.517	Conversion factor, one ton equals 3.516853 kilowatts
8.33	Energy required (BTU‟s), to heat one gallon of water by one degree Fahrenheit
12	kBTUh/ton of air conditioning capacity
67.5	Ambient air temperature °F
91	Days in winter months
274	Days in non-winter months.
365	Days in one year
3.412	Conversion factor, one watt/h equals 3.412142 BTU
3,412	Conversion factor, one kWh equals 3,412 BTU
8,760	Hours in one year
12,000	Conversion factor, one ton equals 12,000 BTU/h
1,000	conversion factor, one kW equals 1,000 Watts
100,000	conversion factor, (BTU/therm), one therm equals 100,000 BTU‟s

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RECORD OF REVISIONS

REVISIONS OF VERSION 1, OCTOBER 15, 2010 MANUAL

Tech Manual Version 1 revisions listed through September 30, 2014, have been included in the "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – *Residential, Multi-family, and Commercial/Industrial Measures, Version 2.*"

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 Multi-family Sections.	N/A – New Measure
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).	Pgs. 212 – 217 & 430 - 435
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
1-13-3	11/26/13	12/1/13-2/28/14	Equivalent 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
9-13-1	9/27/13	10/1/13-12/31/13	Primary Refrigerators	**Refrigerator Rebates**	N/A – New Section

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)
9-13-2	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
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

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)
7-13-5	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
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
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

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)
7-13-15	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 formula 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; for reference 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
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

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)
7-13-27	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
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 formula to derive kW value. (Volts × amps must be divided by 1,000.)	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
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

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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" main 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" main 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
5-11-1	5/6/11	5/6/11	Appendix M	Guidelines for Early Replacement Conditions	On DPS Website
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