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

Residential, Multi-Family, and Commercial/Industrial Measures

October 15, 2010

Prepared for

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Table of Contents

INTRODUCTION

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 cover a variety of measures applicable to the single family, multi-family and commercial/industrial sectors. The approved manuals are as follows:

- New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs in Single Family Residential Measures - Approved December 16, 2009
- New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs in Commercial and Industrial Programs - September 1, 2009
- New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Multi-family Programs July 9, 2009
- New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Gas) March 25, 2009
- New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Electric) December 28, 2008

The Commission requested that the Evaluation Advisory Group[1] (EAG) conduct a detailed review of the manuals to ensure that they are up to date, accurate, and complete. The EAG established a subcommittee to work on this critical assignment. The subcommittee met via teleconference to discuss a series of proposed changes. Thirteen meetings were held over a period of several months addressing proposed changes to the Tech Manual affecting the following:

- Lighting
- HVAC
- Building Types
- Refrigeration
- Water Heating
- Shell and other miscellaneous
- Custom Measures

The subcommittee ultimately submitted to the EAG an extensive list of proposed refinements to the Tech Manuals, including updated formulas, formulas for additional measures, new data tables to clarify specific calculations, additional weather stations and refined protocols for reviewing custom measures. Moreover, efforts were made to improve the "evaluability" of the measures by lining up the parameters in the engineering equations to values that can be measured in the field through the evaluation process.

[1] The Evaluation Advisory Group is an advisory committee with representatives from DPS Staff, Program Administrators, and the Tecmarket Team.

This Tech Manual represents the conclusion of this effort. In addition, the current five manuals are consolidated and streamlined into one manual titled "New York Standard Approach for Estimating Energy Savings – Residential, Multi-Family and Commercial/Industrial Measures." The five manuals were developed and approved over a 12-month period as specific programs were approved resulting in calculations for similar measures appearing in more than one manual. The consolidation and streamlining of these manuals has eliminated redundant information and made the information contained in the manuals easier to find and use.

Peak Demand Definition

The Tech Manual equations are developed to estimate peak electricity savings (kW) along with electricity consumption and gas consumption savings. Equations for estimating peak gas savings will be addressed in a future edition of the Tech Manual. The definition of the peak demand period for electricity and gas peak savings 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 for peak demand calculations. These days conform to the definition above.

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 4^{th} holiday so that the building runs on a non-holiday schedule.

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.

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.

Gas Peak Savings Definition:

Up State: The number of therms saved during a day (24-hour period starting at 10:00AM) in which the average temperature for that day is minus nine (-9F) Fahrenheit (-22.8 degrees Celsius).

Down State: The number of therms saved during a day (24-hour period starting at 10:00AM) in which the average temperature for that day is zero degrees Fahrenheit (-17.8 degrees Celsius).

Ancillary Non-Gas Fossil Fuel Impacts

The measures in the Tech 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

Life-Cycle Savings

The energy savings methodologies presented in this Tech Manual are designed to provide first year annual gross energy savings. Life cycle energy savings and cost benefit calculations are covered under a separate document.

Net to Gross Adjustments

The savings approaches presented in this Tech 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 Tech 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 Tech Manual, or the savings produced using the calculation approaches described in this Tech 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 and for each measure included in this Tech 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 standardize the net impact estimation approach now, a net to gross conversion factor of 0.90 will be applied to the gross saving estimates.

SINGLE AND MULTI-FAMILY RESIDENTIAL MEASURES

CFL

Measure Description

An Energy Star compliant screw-based CFL bulb whose wattage is known. Programs with this characteristic include direct install, catalog, instant and mail-in coupons, and programs such as negotiated cooperative promotions in which product sales at the retail level are reported. The approach below excludes outdoor and common area applications, which tend to have longer run times.

An Energy Star hardwired interior fluorescent fixture with pin based bulbs, including GU24 fixtures, whose wattage is known. Programs focusing on installation of fixtures include new construction and major renovation programs. Fixtures with screw-based (CFL) bulbs are treated as CFL bulbs for savings calculations, and should use the method described in the screw-in CFL section above.

Savings Estimation Approach

Annual Energy Savings = units x leakage x Δ Watts x Hours x Days-per-Year/1000 x (1 + $HVAC_c$)

Demand savings = units x leakage Δ Watts x coincidence factor x (1 + $HVAC_d$)

Therm impacts = Annual Energy Savings x ($HVAC_g$)

Variables and Assumptions

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 bulb that is installed (replacement bulb) or would have been installed (new lamp) and the higher efficiency CFL bulb.

Because the light bulbs are purchased from many product sources (drug stores, supermarkets, hardware stores, discount stores, etc.), and by many people, it is not

practical to obtain information directly from consumers about the wattage of the baseline bulb (what is being replaced or what would have been used instead of the CFL). The alternative approach is to use a method that avoids the need to determine the baseline for each recorded CFL by assuming that the CFL bulb purchased is one of the standard replacement products for the incandescent, in terms of light output equivalency. The method is to assume that the baseline is an incandescent light source with a wattage which is 3.53 times higher than the wattage of the CFL bulb - the general relationship between the equivalency values between incandescents and CFLs, as suggested by the 2008 Database for Energy Efficiency Resources (DEER) study. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

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

3) Hours of bulb 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.[2] 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.[3] This value represents a trade-off among factors which may affect the extent to which any out-of New York State value is applicable to NY. These include such factors as differences among 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

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

[3] 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.

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.[4] 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.[5] The proposed value represents a trade-off among factors which may affect the extent to which any value from outside of New York State is applicable to NY. These include such factors as differences among 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 bulb is on.

Without any indication to the contrary, it is assumed that the bulb 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 and not sold, sold to customers living outside New York State, or placed into storage and not used.

6) Coincidence factors

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

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

5 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.

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

Summary of Variables and Data Sources

Variable	Value	Notes
units		From application, invoices or other documentation. Equal to number of lamps installed and operating.
CFL watts		From application
Δ Watts	2.53 x CFL watts	
Hours per day	3.2 (CFL) 2.5 (CFL fixture)	
Days per year	365	
Coincidence factor	0.08	Use average summer value
HVACc		Vintage and HVAC type weighted average by city (see Appendix D)
HVACd		Vintage and HVAC type weighted average by city (see Appendix D)
HVACg		Vintage and HVAC type weighted average by city (see Appendix D)

References/Sources Reviewed

1. This method is based on the documentation provided in the CL&P and UI Program Savings Documentation for 2008 Program Year. Other similar reports under review include the Efficiency Vermont and Efficiency Maine Technical Reference User Manuals.
2. Impact evaluations of residential lighting programs in several New England states reviewed in preparing the proposed hours-of-use values and coincidence factors include:

Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs, prepared for Cape Light Compact, Vermont Public Service Department, National Grid Massachusetts and Rhode Island, Western Massachusetts Electric Company, NSTAR Electric, Fitchburg G&E by Nexus Market Research Inc., and RLW Analytics Inc., Oct 1, 2004

"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

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

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

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

3. CFL to incandescent wattage equivalency ratios taken from the 2008 Database for Energy Efficiency Resources (DEER) update. See www.deeresources.com for more information.

Revision Number

1

Refrigerators[6]

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

The approach for estimating the savings from early replacement of refrigerators is based on measuring/metering actual energy usage of the refrigerator(s) to be replaced. This approach (referred to as early, short term metering) is established because of the wide variance in potential savings from refrigerator replacement programs that are significantly influenced by the conditions associated with the typical participating facility as well as the program implementation approach. Through this early replacement program, annual savings ranging from a low of 300 kWh per unit, to a high of about 700 kWh per unit are expected. Programs that focus their operations on replacing only the most energy inefficient units will achieve savings near the upper end of this estimated savings range. Programs that do not distinguish the replacement need for each individual unit are expected to have savings near the lower end of this range.

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

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

1. Only replacement of refrigerators that are ten years old or older are eligible for savings claims.
2. Units from 10 to 16 years old will be treated as ***early replacements*** and given full savings relative to the existing unit.
3. Units built before 1994, will be considered ***normal replacements*** and will be given incremental savings. Incremental savings are defined as the difference between the annual kWh consumption of a new unit that is minimally compliant with Federal appliance standards (NAECA) and the new Energy Star unit.

Early Replacement Baseline Refrigerator Energy Consumption

To estimate annual consumption of existing units under an early replacement scenario, the program administrators have the option of testing units one-by-one and making

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

replacement decisions for each unit or selecting a sample of units for testing to make replacement decision for the population of units represented in the sample. If the sample approach is chosen, the program administrators will select a representative sample of refrigerator units to be replaced within a participating multi-family facility. The sample should represent the typical type, size and age of the units to be replaced within the facility. The program administrators will then conduct short term metering on a small sample within the participating facility to establish the projected energy savings from that facility. This effort will be completed early in the program participation process prior to replacements being made at the facility. It is up to the program administrators to identify a sample of refrigerators so that the resulting estimated savings can be expected to be representative of the participating facility. The program administrators are free to set the sample size as long as that sample is no less than the size specified in the following table.

Refrigerator short term metering minimum sample size

Number of units expected to be replaced per facility	Minimum short term metering sample (refrigerators sampled separately using same sampling approach)
10 or less	3*
11 to 20	4
21-50	6
51- 100	8
100-150	10
150-200	12
200-300	17
300 or more	20

*If less than 3 units are projected to be replaced in a facility, sample all units projected to be replaced

For facilities that have identical refrigerators (same make, model, year, size) within the facility, the sample can be focused on those units. For facilities that have a wide mix of brands, models, sizes and ages, the sample should be selected to represent that diversity. In these cases the sample size may need to be larger. However, in no case does the sample *need* to be above 20 units for a participating facility. The evaluation efforts will more accurately estimate ex-post savings as the studies are designed, approved by DPS, and implemented.

Program administrators are free to increase the sample size if they elect to have a more rigorous sampling and estimation process. However, care should be exercised so that the sampled units can be expected to be representative of the typical unit within the facility that is replaced by the program in terms of unit size, age, and design.

Once the sample size and representative units are identified, program administrators will then install short term metering on that sample to obtain a baseline from which savings can be estimated. The metering approach will be conducted in accordance with the following approach.

The units to be tested must be functioning within the dwelling (in situ). The program will arrange for a skilled metering professional to conduct the metering test. The metering

professional will install a digital power meter directly into the refrigerator's power cord. The metering equipment can be selected by the program administrator; however it should be able to record both kW (instantaneous demand) and kWh (energy consumption) and record the number of minutes the unit is being metered. The professional should confirm that the meter has been calibrated according to the manufacturer's recommendations.

The meter should be set to zero at the beginning of each test. The test shall be conducted for a period of time no less than 2 hours, which is the required time to allow the units to stabilize and cycle. While more time would allow increased accuracy, 2 hours is enough time to estimate the amount of energy typically consumed by the unit over a year or 8,760 hours. The resulting total kWh consumed over the metering period will be divided by the number of metering hours and then multiplied by 8760 (hours per year). The resulting energy use calculation will be set for the baseline energy consumption for that metered unit.

Similarly, the unit's average operating baseline demand (kW) will be estimated by dividing the accumulated kWh during the test by the duration of the test (in hours).

The following steps will be used in the metering approach:

<u>Metering Steps</u>

1. *Open door and record the following data:*

   Brand ______________________

   Model Number _________________ *Size* ________________*cu ft*

   Serial Number ______________________

2. *Close Door after compressor comes on and note wattage. (remember to zero the watt meter before starting) Record Running Compression Wattage:*

   ________ *watts*

3. *Let operate normally for two hours or more with door closed and record the total metering minutes and the kWh reading.*

   Total Minutes: _______________ *Total kWh Reading:* ___________

4. *Calculated and record Annual Estimated Energy Consumption* ____ *kWh*

   And Average Demand s ___________ *kW*

<u>Normal Replacement Baseline Refrigerator Energy Consumption</u>

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[7] 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.

Annual Energy and Summer Peak Demand Savings

$$\Delta kW_S = units \times \left[\frac{kWh_{base}}{8760} - \frac{kWh_{ee}}{8760} \right] \times CF_s \times (1 + HVAC_d) \times F_{market}$$

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

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
$\Delta therm$	= gross annual gas impacts from heating system interactions
units	= number of refrigerators installed under the program
kWh_{base}	= annual energy consumption for the replaced unit estimated from short-term test
kWh_{ee}	= annual energy consumption for the new unit from DOE test
CF	= coincidence factor (1.0)
$HVAC_c$	= HVAC system interaction factor for annual energy consumption
$HVAC_d$	= HVAC system interaction factor at utility peak hour
$HVAC_g$	= HVAC system interaction factor for annual gas consumption
8760	= conversion factor (hr/yr)
F_{occ}	= occupant adjustment factor
F_{market}	= market effects factor accounting for replaced refrigerators that enter the used appliance market

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

Occupant Adjustment Factor

The occupant adjustment factor[8] is used to adjust the energy savings according to the number of occupants in the apartment, 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

Market Effects Factor

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

Operating Hours

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

HVAC Interactions

Efficient refrigerators reject less heat into the conditioned space, which must be made up by the space heating system, but can also provide savings on cooling loads. Calculations must include space heating interactions with efficient refrigerators. The HVAC interaction factors calculated from the prototypical building DOE-2 models as a function of the building and HVAC system type are shown in Appendix D.

Notes & References

1. The Energy Star website has a directory of Energy Star qualified refrigerators by make and model number. The directory also lists the baseline energy

[8] The occupant adjustment factor is taken from National Energy Audit Tool (NEAT). Oak Ridge National Laboratory, Oak Ridge, TN. http://weatherization.ornl.gov/national_energy_audit.htm

consumption according to NAECA standards for the size and type of refrigerator purchased. See www.energystar.gov.

2. The occupant adjustment factor is taken from National Energy Audit Tool (NEAT). Oak Ridge National Laboratory, Oak Ridge, TN. http://weatherization.ornl.gov/national_energy_audit.htm
3. Mean life for normal sized refrigerators is assumed to be 17 years. See Preliminary Technical Support Document: Energy Efficiency Program for Consumer Products: Refrigerators, Refrigerator-Freezers, and Freezers. U.S. Department of Energy, November 2009.

Revision Number

1

Refrigerator and Freezer Recycling

Description of Measure

Existing, functional refrigerators or freezers replaced by homeowners often continue to be used as a second refrigerator or freezer, or sold or donated for use elsewhere. Refrigerator and freezer recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing existing, functional refrigerators and freezers from the grid. The savings calculations apply to recycling of a functioning primary[9] or secondary refrigerator.

Annual Energy and Summer Peak Demand Savings

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 also 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 as a result 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[10] until this Tech Manual is updated with values calibrated to the programs operating in New York.

Energy savings per unit:

Refrigerators: 1,655 kWh

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

Freezers: 1,257 kWh

Peak demand savings per unit:

Refrigerators: .046 kW
Freezers: .036 kW

Notes & References

1. Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Program, April 2008, ADM Associates.

Revision Number

2

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.

Savings Estimation Approach

A description of how to calculate lifetime savings using these data is presented in the lifetime savings section below.

Annual Energy Savings

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.

Annual Energy and Resource Savings

$\Delta kWh = \Delta kWh_{washer} + \Delta kWh_{water\ heater} + \Delta kWh_{dryer}$

$\Delta kW = CF * \Delta kWh\ savings / 8760$

$\Delta therm = \Delta therm_{water\ heater} + \Delta therm_{dryer}$

	Efficiency	Clothes Washer		Hot Water Heater		Dryer	
		Electric	Water	Natural Gas	Electric	Natural Gas	Electric
	MEF[11]	(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

Based on data from the Efficiency Vermont TRM, CF = .06

Summary of Variables and Data Sources

Variable	Value	Notes
kWh savings		From table, based on water heater and dryer type
Water heater type		From application
Clothes dryer type		From application
Therm savings		From table, based on water heater and dryer type
Coincidence factor	0.06	

Notes & References

1. Unit energy savings data from the Energy Star website: See http://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

Revision Number

1

[11] 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.

ENERGY STAR Dishwashers

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

Electricity Impact (kWh) = units x $ESav_{DW}$

Demand Impact (kW) = units x $DSav_{REF}$ X CF_{DW}

PAs shall use a deemed unit savings value of 77 kWh per year for homes with gas water heaters, and 137 kWh for homes with electric water heaters. Peak demand savings are deemed at 0.0225 kW per dishwasher.

Summary of Variables and Data Sources

$ESav_{DW}$	Fixed	77 kWh (gas water heater) 137 kWh (electric water heater)
$DSav_{DW}$	Fixed	0.0225
CF_{DW}	Fixed	1.0

Notes & References

1. Unit savings taken from the Energy Star website. www.energystar.gov

Revision Number

0

Opaque Shell Insulation

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

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

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

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

where:

EER_{base} = EER used in the simulations
EER_{part} = EER of cooling systems within participant population
$SEER_{base}$ = SEER used in the simulations
$SEER_{part}$ = SEER of cooling system within participant population
$AFUE_{base}$ = AFUE used in the simulations
$AFUE_{part}$ = AFUE of heating system within participant population
$\bar{\eta}_{dist,base}$ = distribution system seasonal efficiency used in simulations
$\bar{\eta}_{dist,part}$ = distribution system seasonal efficiency within participant population
$\eta_{dist,pk,base}$ = distribution system efficiency under peak conditions used in simulation
$\eta_{dist,pk,part}$ = distribution system efficiency under peak conditions within participant population

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.

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	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 setpoints. See Appendix A for the modeling assumptions for each building prototype.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
SF		From application
ΔkWh/SF		HVAC type weighted average by city based on the combination of the existing and installed R-value
ΔkW/SF		HVAC type weighted average by city based on the combination of the existing and installed R-value
Δtherm/SF		HVAC type weighted average by city based on the combination of the existing and installed R-value
EER_{base}	11.1	
EER_{part}		Participant population average. Defaults to EER_{base} (no adjustment)
$SEER_{base}$	13	
$SEER_{part}$		Participant population average. Defaults to $SEER_{base}$ (no

Variable	Value	Notes
		adjustment)
$AFUE_{base}$	78%	
$AFUE_{part}$		Participant population average. Defaults to $AFUE_{base}$ (no adjustment)
$\bar{\eta}_{dist,base}$	0.956	
$\bar{\eta}_{dist,part}$		Participant population average. Defaults to $\bar{\eta}_{dist,base}$ (no adjustment)
$\eta_{dist,pk,base}$	0.956	
$\eta_{dist,pk,part}$		Participant population average. Defaults to $\eta_{dist,pk,base}$ (no adjustment)
CF_s	0.8	

Notes & 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.

Revision Number

1

High Performance Windows

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = \text{Glazing area (100 SF)} \times (\Delta kW/100\ SF) \times CF_S \times \frac{EER_{base}}{EER_{part}} \times \left[\frac{\eta_{dist,pk,base}}{\eta_{dist,pk,part}}\right]_{cool}$$

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

$$\Delta therm = \text{Glazing area (100 SF)} \times (\Delta therm/\ 100\ SF) \times \frac{AFUE_{base}}{AFUE_{part}} \times \left[\frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,part}}\right]_{heat}$$

where:

EER_{base} = EER used in the simulations
EER_{part} = EER of cooling systems within participant population
$SEER_{base}$ = SEER used in the simulations
$SEER_{part}$ = SEER of cooling system within participant population
$AFUE_{base}$ = AFUE used in the simulations
$AFUE_{part}$ = AFUE of heating system within participant population
$\bar{\eta}_{dist,base}$ = distribution system seasonal efficiency used in simulations
$\bar{\eta}_{dist,part}$ = distribution system seasonal efficiency within participant population
$\eta_{dist,pk,base}$ = distribution system efficiency under peak conditions used in simulation
$\eta_{dist,pk,part}$ = distribution system efficiency under peak conditions within participant population

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.

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	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-deg F, double pane clear glass with a solar heat gain coefficient of 0.62 and U-value of 0.55 Btu/hr-SF-deg 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-deg 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-deg F.

Operating Hours

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

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
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_{base}	11.1	
EER_{part}		Participant population average. Defaults to EER_{base}

Variable	Value	Notes
		(no adjustment)
$SEER_{base}$	13	
$SEER_{part}$		Participant population average. Defaults to $SEER_{base}$ (no adjustment)
$AFUE_{base}$	78%	
$AFUE_{part}$		Participant population average. Defaults to $AFUE_{base}$ (no adjustment)
$\bar{\eta}_{dist,base}$	0.956	
$\bar{\eta}_{dist,part}$		Participant population average. Defaults to $\bar{\eta}_{dist,base}$ (no adjustment)
$\eta_{dist,pk,base}$	0.956	
$\eta_{dist,pk,part}$		Participant population average. Defaults to $\eta_{dist,pk,base}$ (no adjustment)
CF_s	0.8	

Notes & 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.

Revision Number

1

Air Leakage Sealing

Description of Measure

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 Summer Peak Demand and Energy Savings (based on blower door test)

$$\Delta kW_S = \Delta CFM_{50} \ / \text{ n-factor} \times (\Delta kW/CFM) \times CF_S \times \frac{EER_{base}}{EER_{part}} \times \left[\frac{\eta_{dist,pk,base}}{\eta_{dist,pk,part}}\right]_{cool}$$

Gross Annual Energy Savings

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

$$\Delta therm = \Delta CFM_{50} \ / \text{ n-factor} \times (\Delta therm/ CFM) \times \frac{AFUE_{base}}{AFUE_{part}} \times \left[\frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,part}}\right]_{heat}$$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
ΔCFM_{50} = change in infiltration rate (cfm) at measured 50 Pa
n-factor = correction from CFM_{50} to natural infiltration rate
CF = coincidence factor (combined with DF)
$\Delta kW/CFM$ = electricity demand savings per CFM of infiltration reduction
$\Delta kWh/CFM$ = electricity consumption savings per CFM of infiltration reduction
$\Delta therm/CFM$ = gas consumption impact per CFM of infiltration reduction
EER_{base} = EER used in the simulations
EER_{part} = EER of cooling systems within participant population
$SEER_{base}$ = SEER used in the simulations
$SEER_{part}$ = SEER of cooling system within participant population
$AFUE_{base}$ = AFUE used in the simulations
$AFUE_{part}$ = AFUE of heating system within participant population

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

<u>Method for Calculating Summer Peak Demand and Energy Savings (without blower door test)</u>

Gross Summer Coincident Demand Savings
ΔkW_S = Floor area (1000 SF) × (ΔkW/1000 SF) × DF_S × CF_S

Gross Annual Energy Savings
ΔkWh = Floor area (1000 SF) × (ΔkWh/ 1000 SF)

Δtherm = Floor area (1000 SF) × (Δtherm/ 1000 SF)

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
Floor area = Conditioned floor area
DF = demand diversity factor
CF = coincidence factor
ΔkW/1000 SF = electricity demand savings per 1000 SF of conditioned floor area
ΔkWh/1000 SF = electricity consumption savings per 1000 SF of conditioned floor area
Δtherm/ 1000 SF= gas consumption impact per 1000 square foot of conditioned floor area.

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.

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

Baseline natural infiltration rate is assumed be 1 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 setpoints. See Appendix A for the modeling assumptions for each building prototype.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
Floor area		From application
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
ΔkWh/1000 SF		From prototype simulations. Vintage and HVAC type weighted average by city.
ΔkW/1000 SF		From prototype simulations. Vintage and HVAC type weighted average by city.
Δtherm/1000 SF		From prototype simulations. Vintage and HVAC type weighted average by city.
EER_{base}	11.1	
EER_{part}		Participant population average. Defaults to EER_{base} (no adjustment)
$SEER_{base}$	13	
$SEER_{part}$		Participant population average. Defaults to $SEER_{base}$ (no adjustment)
$AFUE_{base}$	78%	
$AFUE_{part}$		Participant population average. Defaults to $AFUE_{base}$ (no adjustment)

$\overline{\eta}_{dist,base}$	0.956	
$\overline{\eta}_{dist,part}$		Participant population average. Defaults to $\overline{\eta}_{dist,base}$ (no adjustment)
$\eta_{dist,pk,base}$	0.956	
$\eta_{dist,pk,part}$		Participant population average. Defaults to $\eta_{dist,pk,base}$ (no adjustment)
CF_s	0.8	

<u>Notes & References</u>

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.

<u>Revision Number</u>

1

Central Air Conditioning

Description of Measure

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.

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{base}} - \frac{12}{EER_{ee}} \right) \times CF_S$$

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
SEER	= seasonal average energy efficiency ratio. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$EFLH_{cooling}$	= cooling equivalent full-load hours
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

The ***SEER*** is an estimate of the average efficiency of the air conditioner over the cooling season at the location of the measure. 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. The SEER is calculated according to AHRI Standard 210/240. 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.

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

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

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

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline and measure efficiency assumptions for air conditioners and heat pumps in several SEER classes are shown below.

Baseline and Measure Efficiency Assumptions

System Type	Baseline or Measure Assumption	Seasonal Efficiency (SEER)	Peak Efficiency (EER)[12]
Central Air conditioner	Early replacement baseline	SEER 10	9.2
	Replace on failure baseline	SEER 13	11.09
	Measure	SEER 14	11.99
		SEER 14.5	12[13]
		SEER 15	12.72
		SEER 16	13.0[14]
		SEER 17	13.0[15]
Central Heat Pump	Early replacement baseline	SEER 10	9
	Replace on failure baseline	SEER 13	11.07
	Measure	SEER 14	11.72
		SEER 14.5	12[16]
		SEER 15	12.5[17]
		SEER 16	12.5[18]
		SEER 17	12.52
		SEER 18	12.8

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

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.

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency for new construction and replace on failure is SEER 13. Baseline for early replacement is SEER 10.

Compliance Efficiency from which Incentives are Calculated

TBD

Operating Hours

The operating hours by climate zone and building vintage are shown above.

Non-Electric Benefits - Annual Fossil Fuel Savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application. Default to average system size from applications if unknown
EER_{base}	11.09	Normal replacement
	9.2	Early replacement
EER_{ee}		Lookup from table, based on unit SEER
	13	Normal replacement
$SEER_{base}$	10	Early replacement
$SEER_{ee}$		From application
CF_s	0.8	
$EFLH_{cooling}$		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.

Notes & 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 http://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

Revision Number

1

Central Air Source Heat Pumps

Description of Measure

A heat pump with improved heating season performance factor (HSPF). Note only the heating savings is presented here; cooling savings from an efficient air source heat pump are covered in the section on central air conditioners.

Method for Calculating Annual Energy Savings

$$\Delta kWh = units \times \frac{kBtuh_{out}}{unit} \times \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right) \times EFLH_{heat}$$

where:

ΔkWh = gross annual energy savings
units = number of heat pumps installed
$kBtuh_{out}$/unit = the nominal rating of the heating output capacity of the heat pump in kBtu/hr (including supplemental heaters)
HSPF = heating seasonal performance factor (Btu/watt-hr), a measure of the seasonal average efficiency of the heat pump in the heating mode
$EFLH_{heat}$ = heating equivalent full-load hours

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.

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/3.413. 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)[19]
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[20]
	SEER 15	8.8
	SEER 16	8.5[21]
	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.

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

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

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

<u>Baseline Efficiencies from which Savings are Calculated</u>

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).

<u>Compliance Efficiency from which Incentives are Calculated</u>

Heat pump efficiency must be greater than or equal to SEER 14.

<u>Operating Hours</u>

Heating equivalent full load hours vary by climate and building vintage. See Appendix G.

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

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated – electric heating system.

Summary of Variables and Data Sources

Variable	Value	Notes
$kBtuh_{out}$/unit		From application
$HSPF_{base}$	8.1	Normal replacement
	6.8	Early replacement
$HSPF_{ee}$		From application
$EFLH_{heat}$		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.

Notes & 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 http://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.

Revision Number

1

Ground Source Heat Pumps

Description of Measure

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 Demand and Energy Savings

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{base,pk}} - \frac{12}{EER_{ee,pk}} \right) \times CF_S$$

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

$$\frac{kBtuh_{out}}{unit} \times \left(\frac{1}{\overline{COP}_{base}} - \frac{1}{\overline{COP}_{ee}} \right) \times \frac{EFLH_{heat}}{3.413}$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
EER_{pk}	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$\overline{EER}$	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
kBtuh/unit	= the heating output capacity rating of the of the heat pump in kBtu/hr
$\overline{COP}$	= average heating season coefficient of performance of heat pump
$EFLH_{cooling}$	= cooling equivalent full-load hours
$EFLH_{heat}$	= heating equivalent full-load hours
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

3.413 = conversion factor (Btu/Wh)

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). Note, the seasonal Baseline systems with electric resistance heat should use a COP of 1.0. Average COP = HSPF/3.413

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 (Cooling Capacity)	-	68°F EWT	4.2 COP	ISO-13256-1
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 changeover 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
Massena	Existing	8	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	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	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

Operating Hours

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

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

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

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

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

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated – electric heating system.

Notes & References

Revision Number

1

Boilers

Description of Measure

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

Method for Calculating Energy Savings

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

where:

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

$$\text{EFLH}_{\text{heat}} = \frac{kBtu_{in} / unit}{kBtuh_{in} / unit},$$

where:

kBtu_{in}/unit = annual gas input rating per unit in kBtu/hr

The ***average seasonal efficiency*** of the 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 boiler 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 boiler manufacturer. Programs should use the manufacturers' rated AFUE until data can be developed that are more appropriate for NY climates.

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

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

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

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency ($\overline{\eta}_{base}$) is as follows:

New construction and replace on failure: minimum AFUE for new boilers per NAECA is 80% for hot water boilers and 75% for steam boilers < 300,000 Btu/hr output.

Compliance Efficiency from which Incentives are Calculated

The measure efficiency ($\overline{\eta}_{ee}$) is as follows:

ACEEE recommends two tiers for hot water boilers: $\geq$85% for non-condensing applications and $\geq$ 90% for condensing applications. Steam boiler efficiency recommendations are: $\geq$ 82% AFUE with electronic ignition.

Operating Hours

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

Summary of Variables and Data Sources

Variable	Value	Notes
$kBtuh_{in}$/unit		From application
$AFUE_{base,}$	0.8	Hot water boiler
	0.75	Steam boiler
	0.78	Furnace
$AFUE_{ee,}$		From application
$EFLH_{heat}$		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.

Notes & References

1. Heating equivalent full load hours assume a 3 degree setback.

Revision Number

0

Boiler Reset Controls

Description of Measure

Reset of hot water setpoint 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 Energy Savings

Δtherm= units × kBtuh$_{in}$/unit × EFLH / 100 × ESF

where:

Δtherm = gross annual gas savings
units = number of boiler reset controls installed
kBtuh$_{in}$/unit = input capacity of boiler served by each reset controller
100 = conversion factor (therm/kBtuh)
EFLH$_{heat}$ = Heating equivalent full load hours
ESF = energy savings factor

The ***input capacity*** (in 1000 Btu/hr) of the boiler should be taken from the application. If the input capacity is not know, then use the following default values:

Single family residential buildings: 110 kBtu/hr

Multi-family building input capacity can be estimated from the building type (lowrise or highrise) 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

City and Vintage	Boiler Size (Btu/hr-SF)	
	High rise (more than 3 stories)	Low rise (3 stories or less)
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

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

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

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

The recommended **Energy Savings Factor (ESF)** for boiler reset controllers in residential applications is 0.05.

Baseline Efficiencies from which Savings are Calculated

Constant hot water setpoint temperature of 180F.

Compliance Efficiency from which Incentives are Calculated

Reset hot water temperature to 160F. Energy Savings Factor (ESF) of 0.05 shall be used.

Operating Hours

Heating equivalent full load hours calculated from building energy simulation models are described in Appendix A and summarized in previous section.

Non-Gas Benefits - Annual Electric Savings

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

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.
$EFLH_{heat}$		Lookup by vintage and city. If vintage not known, use vintage weighted values.
ESF	0.05	

Notes & 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. See: http://www.energysolutionscenter.org/BoilerBurner/Eff_Improve/Efficiency/Boiler_Reset_Control.asp

Revision Number

0

Setback Thermostat

Description of Measure

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 Energy Savings

$$\Delta kWh = units \times \left[\frac{ton}{unit} \times \frac{12}{SEER} \times EFLH_{cool} \times ESF_{cool} + \frac{kBtuh_{out}}{unit} \times \frac{EFLH_{heat}}{HSPF} \times ESF_{heat}\right]$$

$$\Delta therms = units \times \frac{kBtuh_{in}}{unit} \times \frac{EFLH_{heat}}{100} \times ESF_{heat}$$

where:

ΔkWh	= gross annual energy savings
Δtherms	= gross annual gas 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 (Btu/watt-hour)
12	= conversion factor (kBtuh/ton)
ESF	= energy savings factor
$kBtuh_{out}$/unit	= the nominal rating of the heating output capacity of the heat pump in kBtu/hr (including supplemental heaters)
HSPF	= heating seasonal performance factor (Btu/watt-hr), a measure of the seasonal average efficiency of the heat pump in the heating mode
$EFLH_{heat}$	= heating equivalent full-load hours
$EFLH_{cool}$	= cooling equivalent full-load hours

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.

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

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

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

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

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.

<u>Baseline Efficiencies from which Savings are Calculated</u>

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 = 3.413, which is equivalent to a coefficient of performance of 1.0.

Studies of residential heating thermostat setpoint 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.

<u>Efficiency from which Incentives are Calculated</u>

The ***Energy Savings Factor*** for heating (ESF_{heat}) 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 (ESF_{cool}) 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.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application or use 3 as default. Use 0 if no central cooling
$SEER_{base}$	10	
$EFLH_{cool}$		Vintage weighted average by city.
ESF_{cool}	0.09	
If heat pump:		
$kBtuh/unit_{out}$		From application or use 70 kBtu/hr as default
$HSPF_{base}$	6.8	
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
$HSPF_{base}$	3.413	Equivalent to COP = 1
$EFLH_{heat}$		Vintage weighted average by city.
ESF_{heat}	0.068	

Notes & References

1. For examples of studies on residential thermostat setpoint 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 http://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.

Revision Number

0

Refrigerant Charge Correction

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{uncorr}} - \frac{12}{EER_{corr}} \right) \times CF_S$$

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
SEER	= seasonal average energy efficiency ratio. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$EFLH_{cooling}$	= cooling equivalent full-load hours
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

The ***SEER*** is an estimate of the average efficiency of the air conditioner over the cooling season at the location of the measure. The ***SEER*** 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.

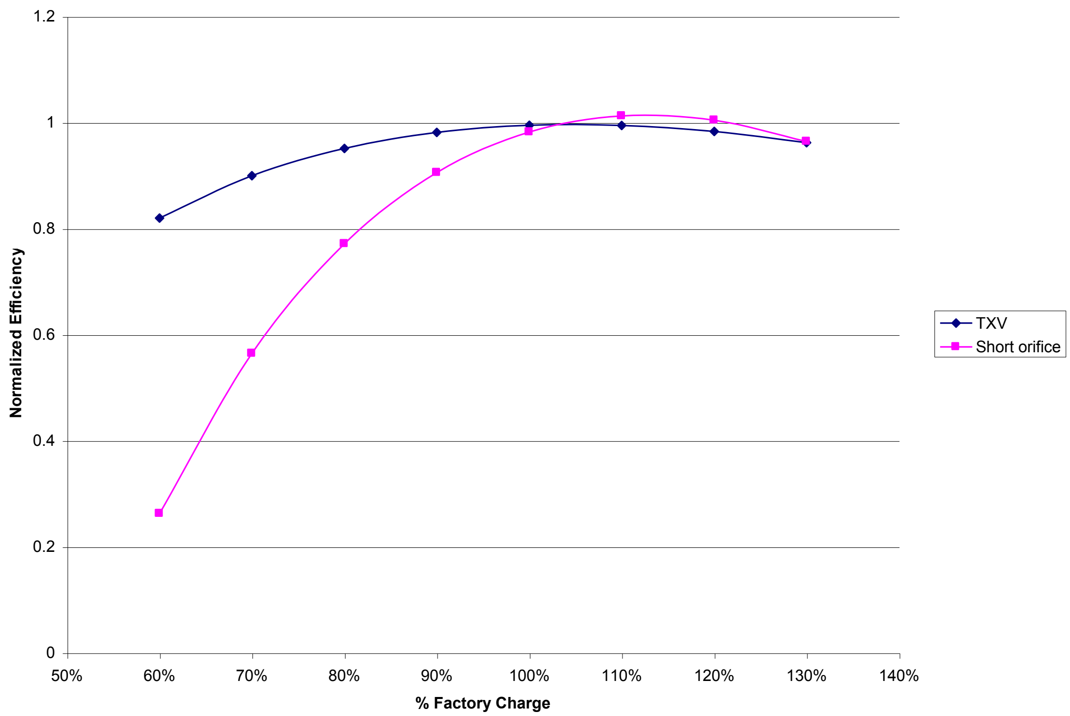
The efficiency improvement resulting from refrigerant charge adjustment depends on how far off the unit was before the adjustment was done, and whether the adjustment was done correctly. The DEER study lists two levels of charge adjustment, with a corresponding efficiency improvement:

• Efficiency gains of 7% for refrigerant charge adjustments less than 20%
• 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. That is, the efficiency of an uncorrected unit is 10% below that of a corrected unit.

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

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[22]. 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

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

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

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

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

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

Recommended value for the coincidence factors is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Cooling equivalent full load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical residential buildings. These data are tabulated in Appendix G.

Baseline Efficiencies from which Savings are Calculated

Use uncorrected efficiency adjustment factor listed above if charge adjustment is not known, or base on actual charge adjustment and figure above.

Compliance Efficiency from which Incentives are Calculated

Use unit nameplate SEER for corrected efficiency or default to SEER 10 if not known.

Operating Hours

Cooling equivalent full load hours vary by city and building vintage. See Appendix G.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
tons	From application	From application or use 3 as default.
$SEER_{corr}$	From application	Unit SEER or 10 as default
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
EER_{uncorr}	From application	Use 0.9 adjustment factor or figure above if charge adjustment data available
$EFLH_{cool}$		Vintage weighted average by city.

Notes & 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 http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

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.

Revision Number

1

Right-Sizing

Description of Measure

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 Summer Peak Demand and Energy Savings

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{12}{EER}\right) \times CF_S \times PSF_d$$

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units covered
tons/unit	= tons of air conditioning per unit, based on nameplate data
SEER	= seasonal average energy efficiency ratio. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$EFLH_{cooling}$	= cooling equivalent full-load hours
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)
PSF_d	= proper sizing factor for demand
PSF_c	= proper sizing factor for consumption

The ***proper sizing factor*** 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.

The ***SEER*** is an estimate of the average efficiency of the air conditioner over the cooling season at the location of the measure. The ***SEER*** 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.

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

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

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

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
EER	11.09	Normal replacement
SEER	13	Normal replacement
CF_s	0.8	
EFLH		Lookup by vintage and city.
PSF_d	0.10	Proctor, 2009
PSF_c	0.03	Proctor, 2009

Notes & References

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

Revision Number

0

Room AC Recycling

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{base}} - \frac{12}{EER_{ee}} \times F_{repl} \right) \times CF_S$$

$$\Delta kWh = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{base}} - \frac{12}{EER_{ee}} \times F_{repl} \right) \times EFLH_{cooling}$$

Where:

ΔkW_s = gross summer coincident demand savings
ΔkWh = gross annual energy savings
units = the number of air conditioning units recycled
tons/unit = tons of air conditioning per unit, based on nameplate data
EER = energy efficiency ratio under peak conditions (Btu/watt-hour)
$EFLH_{cooling}$ = cooling equivalent full-load hours
F_{repl} = fraction of the recycled units that are replaced with a new unit
CF = coincidence factor
12 = conversion factor (kBtuh/ton)

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.

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

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

The cooling EFLH for room air conditioners is deemed at 233 EFLH, based on a study of room air conditioners in New England conducted by RLW Analytics.

The ***replacement factor*** is used to adjust the savings to account for the fraction of recycled units that are replaced with a new unit. A value of 0.76 is recommended, based on a study of room air conditioner recycling conducted in Connecticut by Nexus Market Research and RLW Analytics.

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application; use 0.7 as default.
EER_{base}	7.7	Typical for units replaced
EER_{ee}	9.8	Federal standard; consistent with 0.7 ton size
CF_s	0.8	
EFLH	233	Typical room AC use in New England from RLW Analytics.
F_{repl}	0.76	

Notes & References

1. Only air conditioners that are 5 years old or older are eligible for savings claims.
2. Units from 5 to 10 years old will be treated as ***early replacements*** and use the existing unit as the baseline.
3. 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.
4. EFLH taken from Coincidence Factor Study Residential Room Air Conditioners, conducted by RLW Analytics, 2008.
5. Replacement factor taken from Impact, Process and Market Study of the Connecticut Appliance Recycling Program. Nexus Market Research and RLW Analytics. 2005.

Revision Number

1

EC Motors on Furnace Fans

This section covers the electricity savings associated with electronically commutated (EC) motors used on gas furnace supply fans. Energy and demand saving are realized through reductions in fan power due to improved motor efficiency and variable flow operation. Note: Some homeowners may elect to run their furnace fan continuously to improve air quality and equalize temperatures in the home. This behavior may *increase* energy consumption over a standard furnace fan that operates only on a call for heating. The unit savings number accounts for this effect by reducing the EC motor savings to account for the fraction of homeowners who operate their systems in this manner.

Electricity Impact (kWh) = 733 kWh/furnace

Demand Impact (kW) = 0

The deemed kWh impact is estimated by PA Consulting for the Wisconsin Focus on Energy Program. This value is considered to be representative of EC motor savings in the New York, and accounts for the fraction of homeowners who operate their new furnaces in continuous fan mode.

Summary of Variables and Data Sources

Component	Type	Value	Sources
ΔKWH	Fixed	733	PA Consulting
ΔKW	Fixed	0	Peak savings during cooling mode not considered

Notes & References

1. Deemed kWh savings taken from ECM Furnace Impact Assessment Report. Prepared by PA Consulting for the Wisconsin Public Service Commission, 2009.

Revision Number

0

EC Motors for Hydronic Heating Pumps

Description of Measure

This section covers electronically commutated (EC) motors in hot water circulators.

Method for Calculating Energy Savings

$\Delta kWh = hp \times (1/Eff_{base} - 1/Eff_{ee}) \times 0.746 \times hr$
$\Delta kW = 0$ (no summer peak savings)

where:

ΔkWh = gross annual electricity savings
hp = circulator motor horsepower
Eff_{base} = efficiency of baseline motor
Eff_{ee} = efficiency of EC motor
.746 = conversion factor (kW/hp)
Hr = circulating pump "on" hours

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency of a standard permanent split-capacitor (PSC) motor is estimated to be 50%.

Compliance Efficiency from which Incentives are Calculated

The measure efficiency of a fractional horsepower EC motor is estimated to be 80%.

Operating Hours

Pump on hours are estimated as follows.

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application
EFF_{base}	50%	Typical PSC fractional hp motor
Eff_{ee}	80%	Typical EC fractional hp motor
Hr	3240	National Grid estimate

Notes & References

1. 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.

2. 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.

Revision Number

0

Furnace Tune-up

This section covers tune-ups of residential furnaces to improve the seasonal heating efficiency. The tune-up affects the heating performance only; air conditioning tune-ups are covered in a separate section.

$$\Delta therm = units \times kBtuh_{in}/unit \times EFLH / 100 \times ESF$$

where:

Δtherms = gross annual gas savings
units = number of units installed
kBtuh/unit = the nominal heating input capacity in kBtu/hr
$EFLH_{heat}$ = heating equivalent full-load hours (relative to nameplate)
ESF = energy savings factor

Furnace input capacity is taken from the furnace nameplate. This refers to the fuel input rating of the furnace, in kBtu/hr.

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

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

Heating EFLH are tabulated by building type, vintage and city in Appendix G.

The ***energy savings factor*** for furnace tune-ups is used to estimate the annual heating energy savings. A value of 0.05 is recommended.

Summary of Variables and Data Sources

Component	Type	Value	Sources
kBtuh	Variable		Program Application
EFLH	Fixed		Lookup based on vintage and location
ESF	Fixed	0.05	

Notes & 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.

Revision Number

0

High Efficiency Gas Furnaces

Description of Measure

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

Method for Calculating Energy Savings

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

where:

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

The ***heating input capacity*** is the nameplate rated input in kBtu/hr.

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

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

Heating equivalent full-load hours for single family and multi-family 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 as a function of building type, vintage and city are shown in 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.

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency $AFUE_{base}$ for new construction and replace on failure:

Minimum AFUE for new gas furnaces per NAECA is 78%. Common practice generally leads code, but there are no New York specific baseline data on baseline furnace efficiency available at this time.

Compliance Efficiency from which Incentives are Calculated

The measure efficiency $AFUE_{ee}$ is as follows:

ACEEE recommends two tiers: > 92% and > 95% AFUE.

Operating Hours

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

Non-Gas Benefits - Annual Electric Savings

EC 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.

Summary of Variables and Data Sources

Variable	Value	Notes
$kBtuh_{in}$/unit		From application
$AFUE_{base,}$	0.8	Hot water boiler
	0.75	Steam boiler
	0.78	Furnace
$AFUE_{ee,}$		From application
$EFLH_{heat}$		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.

Notes & 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

Revision Number

1

Duct Insulation and Leakage Sealing

Description of Measure

Improvements to duct systems made separately or in conjunction with high efficiency furnace, heat pump, or air conditioner installation.

Method for Calculating Energy Savings

$$\Delta kWh = units \times \left[\frac{ton}{unit} \times \frac{12}{SEER} \times EFLH_{cool} \times \left[1 - \frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,ee}}\right]_{cool} + \frac{kBtuh_{out}}{unit} \times \frac{EFLH_{heat}}{HSPF} \times \left[1 - \frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,ee}}\right]_{heat}\right]$$

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

$$\Delta therms = units \times \frac{kBtuh_{in}}{unit} \times \frac{EFLH_{heat}}{100} \times \left[1 - \frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,ee}}\right]_{heat}$$

where:

Δ kWh	= gross annual electricity (kWh). savings
Δ kW	= gross peak demand (kW). savings
Δtherms	= gross annual gas savings
units	= number of units treated
$kBtuh_{in}$/unit	= the nominal input rating of the heating capacity of the furnace
$kBtuh_{out}$/unit	= the nominal output rating of the heating capacity of the heat pump
ton/unit	= the nominal rating of the cooling capacity of the air conditioner or heat pump in tons
SEER	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
HSPF	= average heating season efficiency of heat pump (Btu/watt-hour)
$\bar{\eta}_{dist}$	= duct system average seasonal efficiency
η_{dist}	= duct system efficiency under peak conditions
$EFLH_{cool}$	= cooling equivalent full load hours
$EFLH_{heat}$	= heating equivalent full load hours
CF	= coincidence factor
100	= conversion factor (kBtuh/therm)

The ***heating input capacity*** is the nameplate rated input in kBtu/hr.

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.

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

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

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

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

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

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.

Duct system efficiencies The cooling and heating season average distribution efficiencies for duct systems in residential buildings across six 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.

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline HSPF for heat pumps should be set according to the method described in the sections on heat pump efficiency. The baseline efficiency ($\overline{\eta}_{base}$) for furnaces should be set according to the method described in the sections on furnace efficiency. Distribution system efficiency ($\overline{\eta}_{\text{dist,base}}$) 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 ($\overline{\eta}_{\text{ee}}$) for furnaces should be set according to the section on efficient furnaces. Distribution system efficiency ($\overline{\eta}_{\text{dist,ee}}$) should be based on measured duct leakage if available. If 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 and summarized in previous section.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
SEER	10	existing unit
	13	new construction

Variable	Value	Notes
$\bar{\eta}_{dist,base}$	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.
$EFLH_{cool}$		Vintage weighted average by city.
EER_{base}	9.2	existing unit
	11.1	new unit
$\eta_{dist,base}$	$\bar{\eta}_{dist,base}$	
$\eta_{dist,ee}$	$\bar{\eta}_{dist,ee}$	
CF_s	0.8	
If heat pump:		
$kBtuh/unit_{out}$		From application
HSPF	6.8	existing unit
	8.1	new unit
if furnace		
$kBtuh_{in}/unit$		From application
$\bar{\eta}_{dist,base}$	0.934	Statewide average based on uninsulated duct with 20% leakage. Measured leakage OK if available.
$\bar{\eta}_{dist,ee}$		Statewide average; specs based on new vs. existing construction. Measured leakage OK if available. Use appropriate R-value if duct insulation is also included.
$EFLH_{heat}$		Vintage weighted average by city.

Notes & 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 air flow.

Revision Number

1

Room Air Conditioner

Description of Measure

Room air conditioners installed in single family and multi-family residential buildings.

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = \text{units} \times \frac{\text{tons}}{\text{unit}} \times \left(\frac{12}{EER_{base}} - \frac{12}{EER_{ee}} \right) \times CF_S$$

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

where:

ΔkW_s	= gross coincident summer demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
$\overline{EER}$	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
EFLH	= cooling equivalent full-load hours
CF_s	= summer coincidence factor
12	= conversion factor (kBtuh/ton)

The ***EER*** refers to the rated full-load efficiency of the air conditioner

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

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

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	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

The cooling EFLH for room air conditioners is deemed at 233 EFLH, based on a study of room air conditioners in New England conducted by RLW Analytics.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
EER_{base}		Lookup from table
EER_{ee}		From application
$\overline{EER}_{base}$	EER_{base}	
$\overline{EER}_{ee}$	EER_{ee}	
CF_s	0.8	
$EFLH_{cool}$	233	Deemed value based on RLW Analytics study

Notes & References

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

Revision Number

1

Water Heater

Description of Measure

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

Method for Calculating Energy Savings

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

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

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
$\Delta therm$	= gross annual gas savings
units	= number of high efficiency water heaters installed under the program
UA_{base}	= overall heat loss coefficient of base water heater (Btu/hr-°F)
UA_{ee}	= overall heat loss coefficient of efficient water heater (Btu/hr-°F)
ΔT_s	= temperature difference between the stored hot water and the surrounding air (°F)
GPD	= average daily water consumption (gallons/day)
$\overline{\Delta T}_w$	= average difference between the cold inlet temperature and the hot water delivery temperature (°F)
EF_{base}	= baseline water heater energy factor
EF_{ee}	= efficient water heater energy factor
DF	= demand diversity factor
CF	= coincidence factor
3413	= conversion factor (Btu/kWh)
8.3	= conversion factor (Btu/gallon-°F)
100,000	= conversion factor (Btu/therm)
365	= conversion factor (days/yr)

The ***ambient temperature difference*** between the water heat setpoint 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 setpoint 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 setpoint temperature. Water heater setpoint for residential buildings is usually in the range of 120°F to 140°F. The water heater setpoint 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 mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.3
NYC	56.5	62.5

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

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

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

Tank overall heat loss coefficient (UA[23]) is used to calculate the summer peak savings, which are assumed to be caused by reductions in standby losses. The UA is calculated from the energy factor, recovery efficiency, and heater electric element or gas burner capacity:

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

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

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

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

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

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

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

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

Electric water heaters: EF = 0.93-0.00132V
Gas water heaters: EF = 0.62-0.0019V

[23]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.
[24] Values applicable to non-condensing water heaters with EF ≤ 0.68.

where V is tank volume in gallons.

Compliance Efficiency from which Incentives are Calculated

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

Electric: $EF \geq .93$

Gas: $EF \geq .65$

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

Gas: EF > .82 plus electronic ignition

Operating Hours

Water heater assumed to be available at all hours.

Non-Electric Benefits - Annual Fossil Fuel Savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		Calculated from EF and RE
UA_{ee}		Calculated from EF and RE
delta T_s	Tset - Tamb	
GPD	78	Default for SF. Use GPD based on number of units for MF.
delta T_w	Tset - Tmain	
EF_{base}		Calc from tank volume and fuel type
EF_{ee}		From application
Tank volume		From application
T_{set}	130	
T_{amb}	65	
T_{mains}		Avg T_{mains} based on upstate or downstate
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)
RE	0.97	Electric
	0.75	Gas
CF_s	1	

Notes & References

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

Revision Number

1

Indirect Water Heaters

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

Method for Calculating Energy Savings

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

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

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

where:

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

100,000 = conversion factor (Btu/therm)
365 = conversion factor (days/yr)

The ***ambient temperature difference*** between the water heat setpoint 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 setpoint 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 setpoint temperature. Water heater setpoint for residential buildings is usually in the range of 120°F to 140°F. The water heater setpoint 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 mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.3
NYC	56.5	62.5

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

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

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

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:

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

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

Standard assumptions for recovery efficiency and input capacity for small 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)*** for larger multi-family water heaters is calculated from the standby loss specification.

UA = SL/70 (Btu/hr-deg F)

where:

SL = standby loss (Btu/hr)
70 = temperature difference associated with standby loss specification

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

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

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)

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

r_1 = radius of bare tank (ft)
r_2 = radius of tank plus existing insulation (ft)
r_3 = radius of tank plus existing insulation plus additional insulation (ft)
H = height of tank (ft)
th_{bot} = thickness of insulation on tank bottom (ft)
th_{top} = thickness of insulation on tank top (ft)
th_{wrap} = thickness of tank wrap (ft)

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

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

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

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

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

Electric water heaters: EF = 0.93-0.00132V
Gas water heaters: EF = 0.62-0.0019V

where V is tank volume in gallons.

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		Calc from baseline water heater EF or standby loss.
UA_{ee}		Calc from lookup table based on tank volume and insulation thickness
delta T_s	Tset - Tamb	
GPD		Default to 78 gpd for single family residential, otherwise from application
delta T_w	Tset - Tmain	
Ec_{base}	0.97 (elec)	
	0.75 (gas)	
Ec_{ee}		From application
V		From application
T_{set}	130	
T_{amb}	65	
T_{mains}		Avg T_{mains} based on upstate or downstate
Capacity (Q)	40,000	See table for storage type gas water heaters above
EF_{base}		Calc from tank volume
RE_{base}		0.75
V_{base}		Same as V
SL_{base}	380 Btu/hr	Based on 120 gal tank with 2 in foam insulation

Notes & References

Revision Number

0

Heat Pump Water Heater

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

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

ΔkW_S = 0.5

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= number of high efficiency water heaters installed under the program
GPD	= average daily water consumption (gallons/day)
$\overline{\Delta T}_w$	= average difference between the cold inlet temperature and the hot water delivery temperature (°F)
EF_{base}	= baseline water heater energy factor
EF_{ee}	= efficient water heater energy factor
3413	= conversion factor (Btu/kWh)
8.3	= conversion factor (Btu/gallon-°F)
365	= conversion factor (days/yr)

The ***water temperature difference*** between the water heat setpoint 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 setpoint temperature. Water heater setpoint for residential buildings is usually in the range of 120°F to 140°F. The water heater setpoint 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 mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.3
NYC	56.5	62.5

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

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

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

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

Electric water heaters: EF = 0.93-0.00132V
Gas water heaters: EF = 0.62-0.0019V

Where: V is tank volume in gallons.

Compliance Efficiency from which Incentives are Calculated

Average energy factor for heat pump water heaters is 2.2.

Operating Hours

Water heater assumed to be available at all hours.

Non-Electric Benefits - Annual Fossil Fuel Savings

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

Summary of Variables and Data Sources

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

Notes & References

1. Average hot water use per person taken from: Lutz, James D., Liu, Xiaomin, McMahon, James E., Dunham, Camilla, Shown, Leslie J.McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996..
2. Average annual outdoor temperature taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE-2.2 weather data statistics package. www.nrel.gov
3. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.

Revision Number

0

Low Flow Showerheads

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.

Savings Estimation Approach – Method and Results[26]

Annual Energy Savings

Method

The savings estimations were derived through the following steps:

1. Develop estimate of annual gallons of water saved from the measure

Water Savings = ((GPM_{base} – GPM_{ee}) X (throttle factor) X (minutes/shower) X (#showers/day) X 365 (days/year))

Recommended values are shown in the Table below.

Parameter	Value	Source
GPM_{base}	3.25	LBNL study
GPM_{ee}		Program tracking data on rebated showerhead flowrate
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	2	

2. Calculate the amount of heat required to heat that much water.

kWh Savings =((water savings x (temp to shower-temp to heater) x (8.3BTU per gallon) / (3414 Btu/kWh)) /water heater $efficiency_{elec}$

therm Savings =((water savings x (temp to shower-temp to heater) x (8.3BTU per gallon) / (100,000 Btu/therm)) /water heater $efficiency_{gas}$

The typical value for water temperature leaving the shower is 105 degrees F. Inlet water temperature by location is shown below.

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

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

Standard assumptions for water heater efficiency are listed below.

Water Heater Type	Water heater efficiency
Electric	0.97
Gas	0.75

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		From application
GPM_{base}	3.25	
Throttle factor	0.75	
Min/shower	8	
Shower/day	2	
T_{shower}	105	
T_{mains}		Avg T_{mains} based on upstate or downstate
Water heater effic	0.97	Electric
	0.75	Gas

Notes & References

1. Average hot water use per person taken from: Lutz, James D., Liu, Xiaomin, McMahon, James E., Dunham, Camilla, Shown, Leslie J.McCure, Quandra T; “Modeling patterns of hot water use in households;” LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996..
2. Average annual outdoor temperature taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE-2.2 weather data statistics package. www.nrel.gov
3. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; “Towards Development of an Algorithm for Mains Water Temperature.” National Renewable Energy Laboratory.

Revision Number

0

Faucet Aerators

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.

Savings Estimation Approach – Method and Results[27]

Annual Energy Savings

Method

The savings estimations were derived through the following steps:

1. Develop estimate of annual gallons of water saved from the measure

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

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.[28]

Water Savings (Gallons/year)

Standard aerator (GPM)	2.2
Replacement low flow aerator (GPM)	1.5
Savings in GPM	0.7
Duration of use (minutes)	0.5
No. of uses/day	30
Days/year	365
Gallons of water saved/year	3,830

2. Calculate energy savings

kWh Savings =((water savings x (temp faucet-temp to heater) x (8.3BTU per gallon) / (3413Btu/kWh)) /water heater $efficiency_{elec}$

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

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

therm Savings =((water savings x (temp faucet-temp to heater) x (8.3BTU per gallon) / (100,000Btu/therm)) /water heater efficiency$_{gas}$

Typical value for water temperature leaving the faucet is 80 degrees F. Inlet water temperature by location is shown below.

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

Standard assumptions for water heater efficiency are listed below.

Water Heater Type	Water heater efficiency
Electric	0.97
Gas	0.75

Summary of Variables and Data Sources

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

Notes & 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. http://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.

Revision Number

1

Hot Water Tank Insulation

Description of Measure

This section covers additional thermal insulation blankets for storage-type gas water heaters. These blankets are intended to reduce standby heat losses through the side of the water heater.

Method for Calculating Energy Savings

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

$$\Delta kWh = units \times \frac{(UA_{base} - UA_{ee}) \times \overline{\Delta T}}{3413 \times \eta_{elec}} \times 8760$$

$$\Delta therm = units \times \frac{(UA_{base} - UA_{ee}) \times \overline{\Delta T}}{\eta_{gas}} \times \frac{8760}{100000}$$

where:

ΔkW	= gross coincident peak demand savings
ΔkWh	= gross annual electricity savings
Δtherm	= gross annual gas savings
units	= number of water heaters installed under the program
UA_{base}	= overall heat transfer coefficient of base water heater (Btu/hr-°F)
UA_{ee}	= overall heat transfer coefficient of improved water heater (Btu/hr-°F)
ΔT	= temperature difference between the water inside the tank and the ambient air (°F)
DF	= demand diversity factor
CF	= coincidence factor
3413	= conversion factor (Btu/kWh)
8760	= conversion factor (hr/yr)
100000	= conversion factor (Btu/therm)
η_{elec}	= electric water heater efficiency
η_{gas}	= gas water heater efficiency

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	UAbase	UAee
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)	UAbase (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
400	97	36	95.3	23.3	11.9	18.5	9.5
500	74	48	115.9	26.3	13.3	20.9	10.6
750	106	48	146.9	34.9	17.7	27.7	14.1
1000	138	48	177.9	43.5	22.1	34.6	17.6

Water heater size (gal)	Height (in)	Diameter (in)	UAee (Btu/hr-F) 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
1000	138	48	22.1	16.1	11.5	14.4	10.0

The ***efficiency*** of an electric storage type water heater is assumed to be 0.97. The ***combustion efficiency*** of a non-condensing storage type water heater is assumed to be 0.75.

The ***ambient temperature difference*** between the water heat setpoint 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 setpoint temperature of 130°F is the default value.

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

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The UA_{base} for existing water heaters were calculated assuming 1 inch of high density polyurethane foam insulation as the factory standard insulation level.

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.

Deemed Savings Values

Deemed savings per water heater wrap are shown in the Table below.

Parameter	Electric water heater	Gas water heater
Water heater size	50 gal	40 gal
UA_{base}	4.49	4.58
UA_{ee}	1.96	2.00
ΔT_s	60°F	60°F
ΔT	60°F	60°F
η	0.97	0.75
ΔkW	0.046	
ΔkWh	402	
Δtherm		18.1

Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		lookup based on tank volume

UA_{ee}		lookup based on tank volume
delta T_s	T_{set} - T_{amb}	
Water heater effic	0.97	Electric
	0.75	Gas
Tset	130	
Tamb	65	
CFs	1	
Tank volume	50	Electric (default for SF and single unit MF, use application for central MF)
	40	Gas (default for SF and single unit MF, use application for central MF)

Notes & 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.

Revision Number

1

Pipe Insulation

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

Method for Calculating Energy Savings

$$\Delta kW_S = L \times \frac{\left[(UA/L)_{base} - (UA/L)_{ee}\right]}{\eta_{heater} \times 3413} \times \Delta T_S \times CF_S$$

$$\Delta kWh = L \times \frac{\left[(UA/L)_{base} - (UA/L)_{ee}\right]}{\eta_{heater} \times 3413} \times \overline{\Delta T} \times hr$$

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
L	= length of insulation installed
ΔT	= temperature difference between water within the pipe and air under peak conditions
$\overline{\Delta T}$	= average temperature difference between water within the pipe and air temperature (°F)
UA/L	= overall pipe heat loss coefficient per unit length (Btu/hr-°F-ft)
CF	= coincidence factor
3412	= conversion factor (Btu/kWh)
8760	= conversion factor (hr/yr)
100,000	= conversion factor (Btu per therm)
η_{heater}	= water heater or boiler efficiency

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

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

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

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

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

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

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

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

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

An average water temperature of 160°F is the default value for hot water boilers, and an average steam pipe temperature of 190°F is the default value for steam boilers.

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

The recommended value for the coincidence factor is shown below.

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

<u>Baseline Efficiencies from which Savings are Calculated</u>

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

<u>Compliance Efficiency from which Incentives are Calculated</u>

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

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

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

<u>Operating Hours</u>

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

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

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

Variable	Value	Notes
L	From application	
ΔT	60°F (service hot water) 100°F (hot water heat) 130°F (steam heat)	130°F hot water temp, 70°F room temp 160 °F hot water temp, 60°F room temp 190 °F steam temp, 60°F room temp
$\overline{\Delta T}$	60°F (service hot water)	130°F hot water temp, 70°F room temp

	100°F (hot water heat) 130°F (steam heat)	160 °F hot water temp, 60°F room temp 190 °F steam temp, 60°F room temp
UA/L	From table above	Pick value based on pipe size, insulation type and insulation thickness
CF	1.0	
η_{heater}	0.97 (elec water heater) 0.75 (gas water heater) 0.80 (gas hot water heat) 0.75 (gas steam heat)	
hr	Service hot water: 8760hr Space Heat: $EFLH_{heat}$ (SF and MF lowrise) 3240 (MF highrise)	$EFLH_{heat}$ from Appendix G.

Notes & References

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

Revision Number

1

Energy Star Dehumidifier

The general algorithm for Energy Star dehumidifiers is:

Number of Units X Savings per Unit

Electricity savings from the Energy Star calculator are shown below.

Dehumidifier	kWh savings
1-25 pints/day	54 kWh
25-35 pints/day	117 kWh
35-45 pints/day	213 kWh
45-54 pints/day	297 kWh
54-75 pints/day	42 kWh
75-185 pints/day	374 kWh

To determine the savings, the per unit estimates in the algorithms will be multiplied by the number of units. Demand savings are estimated to be 0.0098 kW/unit.

Summary of Variables and Data Sources

Variable	Value	Notes
kWh savings		Lookup based on capacity (pints per day)
Capacity (pints/day)		From application
kW savings	0.0098	

References:

1. ENERGY STAR Dehumidifier Savings Calculator (Calculator updated: 2/15/05; Constants updated 05/07). A weighted average based on the distribution of available ENERGY STAR products was used to determine savings.
2. Demand savings from Energy-Efficiency and DSM Rules for Pennsylvania's Alternative Energy Portfolio Standard. Technical Reference Manual. September 7, 2005.

Revision Number

0

Submetering

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

kWh = kWh/SF x SF x ESF

where:

kWh/SF = annual electricity consumption per SF of conditioned floor area
SF = conditioned floor area per apartment subject to submetering
ESF = energy savings factor from submetering

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. The default value of ESF is set at 0.08.

There is a significant research literature substantiating the belief that submetering 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 submetering 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 submetering be rigorously evaluated through ex-post studies.

Baseline Efficiencies from which Savings are Calculated

N/A

Compliance Efficiency from which Incentives are Calculated

N/A

Operating Hours

N/A

Incremental Cost

N/A

Notes & References

"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.

"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.

National Multiple Family Submetering and Allocation Billing Program Study. Prepared by Aquacraft for the UP EPA. August 2004.

Revision Number

1

COMMERCIAL AND INDUSTRIAL MEASURES

Interior and Exterior Lighting

Description of Measure

This section covers energy-efficient lighting equipment, such as energy-efficiency lamps, energy-efficiency ballasts, compact fluorescent lamps, and improved lighting fixtures. Energy-efficient lamps may include fluorescent 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 Summer Peak Demand and Energy Savings

$$\Delta kW_s = \left[\frac{(Watts \times units)_{base} - (Watts \times units)_{ee}}{1000}\right] \times CF \times (1 + HVAC_{d,s})$$

$$\Delta kWh = \left[\frac{(Watts \times units)_{base} - (Watts \times units)_{ee}}{1000}\right] \times FLH \times (1 + HVAC_c)$$

$$\Delta therm = \Delta kWh \text{ x } HVAC_g$$

where:

ΔkW_s = gross summer coincident demand savings

ΔkWh = gross annual energy savings

$\Delta therm$ = gas impacts from heating interactions

units = number of units installed under the program
$Watts_{ee}$ = connected load of the energy-efficient unit
$Watts_{base}$ = connected load of the baseline unit(s) displaced
FLH = full-load operating hours
CF = coincidence factor
$HVAC_{d,s}$ = HVAC system interaction factor at utility summer peak hour
$HVAC_c$ = HVAC system interaction factor for annual energy consumption
$HVAC_g$ = HVAC system interaction factor for gas

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

Watts$_{base}$ is defined as the fixture wattage of the baseline lighting fixture. The baseline condition is assumed to be the existing lighting fixture in retrofit applications. 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 energy codes. In these instances, the 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:

$$\Delta kW_s = \text{area x} \left[\frac{(LPD)_{base} - (LPDs)_{ee}}{1000} \right] \times CF \times (1 + HVAC_{d,s})$$

$$\Delta kWh = \text{area x} \left[\frac{(LPD)_{base} - (LPD)_{ee}}{1000} \right] \times FLH \times (1 + HVAC_c)$$

$$\Delta therm = \Delta kWh \text{ x } HVAC_g$$

where:

LPD_{base} = baseline lighting power density (W/SF)
LPD_{ee} = installed system lighting power density (W/SF)
Area = floor area illuminated by lighting system (SF)

Code LPD shall be taken from New York State Energy Conservation Code which is based on ASHRAE 90.1-2007. Use the appropriate LPD based on the building type or space occupancy as applicable.

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

Facility Type	Lighting Hours	HVAC Int	Facility Type	Lighting Hours	HVAC Int
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
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

The ***coincidence factor*** is 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.

Recommended value for the coincidence factor is shown below.

Parameter	Interior Lighting	Exterior Lighting
Coincidence factor	1.0	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 which 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 lighting fixture in retrofit applications. Note, depending on local codes, new construction, space renovations or remodels may require a building permit that includes compliance with local energy codes. In these instances, the 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.

Non-Electric Benefits - Annual Fossil Fuel Savings

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.

Summary of Variables and Data Sources

Variable	Value	Notes
$Units_{base}$		From application. Set equal to $Units_{ee}$ if unknown
$Units_{ee}$		From application
Wattsee		From application
Wattsbase		From application
FLH		From application or default table in Manual
LPD_{base}		From application, based on NY State Energy Conservation code. New construction or major renovation only.
LPD_{ee}		From application, based on installed system design. New construction or major renovation only.

Variable	Value	Notes
CF_s	1.0	Interior lighting
	0.0	Exterior lighting
HVACd		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
HVACc		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
$HVAC_g$		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

Notes & 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

Revision Number

1

Interior Lighting Controls

Description of Measure

This section covers lighting control measures, including occupancy sensors, photocell controls, timeclocks, daylighting 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.

$$\Delta kW_s = units \times \left(\frac{Watts_{ctrl}}{1{,}000}\right) \times DSF_s \times (1 + HVAC_{d,s})$$

$$\Delta kWh = units \times \left(\frac{Watts_{ctrl}}{1{,}000}\right) \times (FLH_{base} - FLH_{ee}) \times (1 + HVAC_c)$$

$$\Delta therm = \Delta kWh \text{ x } HVAC_g$$

where:

ΔkW_s = gross summer coincident demand savings

ΔkWh = gross annual energy savings

Units = number of control units installed under the program

$Watts_{ctrl}$ = connected load of controlled lighting fixtures

DSF_s = coincident demand savings factor

FLH = full-load operating hours

$HVAC_c$ = HVAC system interaction factor for annual energy consumption

$HVAC_d$ = HVAC system interaction factor at utility peak hour

$HVAC_g$ = HVAC system interaction factor for gas

$Watts_{ctrl}$. is the connected load of the lighting equipment controlled.

$Watts_{ctrl}$ is the connected load of the lighting equipment controlled.

The ***demand savings factor*** 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.

Demand Savings Factors for Various Automatic Control Options

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

The ***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 ***coincidence factor*** is 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.

Recommended value for the coincidence factor is shown below.

Parameter	Interior Lighting	Exterior Lighting
Coincidence factor	1.0	0.0

HVAC system interaction factors. 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

See section on commercial lighting systems above.

Non-Electric Benefits - Annual Fossil Fuel Savings

Reduction in lighting power increases space heating requirements. Interactions with the heating system must be applied to the calculations, as described above.

Notes & References

1. Energy and demand savings factors derived from lighting control power adjustment factors prescribed in the California Title 24 Nonresidential lighting standards.

Summary of Variables and Data Sources

Variable	Value	Notes
Units		From application
Wattsctrl		From application
Control type		From application
DSF		Lookup based on control type
FLH_{base}		From application
FLH_{ee}		From application
HVACd		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
HVACc		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC. Use 0 for lights in unconditioned space.
$HVAC_g$		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

Revision Number

1

Refrigerators

Description of Measure

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

$$\Delta kW_S = units \times \left[\frac{kWh_{base}}{8760} - \frac{kWh_{ee}}{8760}\right] \times CF_s \times (1 + HVAC_d) \times F_{market}$$

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

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
$\Delta therm$	= gross annual gas impacts from heating system interactions
units	= number of refrigerators or freezers installed under the program
kWh_{base}	= annual energy consumption for the baseline unit
kWh_{ee}	= annual energy consumption for the new unit
CF	= coincidence factor (1.0)
$HVAC_c$	= HVAC system interaction factor for annual energy consumption
$HVAC_d$	= HVAC system interaction factor at utility peak hour
$HVAC_g$	= HVAC system interaction factor for annual gas consumption
8760	= conversion factor (hr/yr)

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).

The ***coincidence factor*** is defined as the fraction of the end-use demand that is coincident with the utility system peak. The default value for 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

Energy Star rating required.

Operating Hours

Unit is assumed to run year-round.

Non-Electric Benefits - Annual Fossil Fuel Savings

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.

Summary of Variables and Data Sources

Variable	Value	Notes
V		From application
kWh_{base}		Calculated from volume and type using equations above
kWh_{ee}		Calculated from volume and type using equations above
CF	1.0	
$HVAC_c$		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC.
$HVAC_d$		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC.
$HVAC_g$		Lookup by building type with weighted average across HVAC types. Average upstate values or NYC.

Notes & References

1. US EPA energy consumption for Energy Star commercial refrigerators obtained from the Energy Star website: http://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: http://www.fishnick.com/saveenergy/tools/calculators/

Revision Number

1

Refrigerated Case LEDs

Measure Description

The installation of LED bulbs 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 light is on, and by adding heat to the inside of the unit that must be overcome through additional cooling. Replacing fluorescent lighting with low heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of waste heat generated from the lighting that must be overcome by the unit's compressor cycles.

Savings Estimation Approach

Annual Savings

kWh Savings

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.

The estimation approach is as follows:

Savings in kWh per year = (Annual lighting kWh B – Annual lighting kWh A) + ComEffSav

Where:

Annual lighting kWh B	= The total annual kWh usage of the unit per year with conventional baseline lighting.
Annual lighting kWh A	= The total annual kWh usage of the units with the LEDs installed.
ComEffSav	= the kWh savings of the refrigeration unit by not needing to cool the heat generated by the inefficient lighting.
kWh B	= total lighting run hours per year x wattage of baseline lighting / 1000
kWh A	= total lighting run hours per year x wattage of LED lighting / 1000

The ComEffSav from the compressor are estimated using the following approach:

ConEffSav = (Annual lighting kWh B – Annual lighting kWh A) * ComEffFac

Where:

ComEffFac = 0.51 for coolers and 0.65 for freezers * 0.8 for the portion of the saved energy that would have needed to be eliminated via the compressor[29]. Thus, ComEffFac for refrigerators and coolers = (0.51 * .8) = 0.41 and ComEffFac for freezers = (0.65 * .8) = 0.52.

kW Savings

Peak demand savings are calculated using the following approach.

KW = (kW B – kW A)* (1 + Compressor factor)

Where:

KW	= the total average kW savings of the refrigeration system, including both the kW reduction due to the bulb replacement and the kW reduced from the operation of the compressor not having to remove the excess lighting.
kW B	= The total power usage of the lighting fixtures that are being replaced, kW.
kW A	= The total power usage of the new lighting fixtures that are being installed.
Compressor factor	= 0.40 for coolers and 0.51 for freezers. The factors are based on effective refrigeration compressor EER values of 6.7 (1.8 kW/ton) and 5.25 Btu/Wh (2.3 kW/ton), respectively, and the assumption that 20% of the case lighting load is not converted into a case cooling load. Compressor factor (coolers) = 0.28 ton/kW * 1.8 kW/ton * 0.8 = 0.40
Compressor factor (freezers)	= 0.28 ton/kW * 2.3 kW/ton * 0.8 = 0.51

Gross kWh Savings = (Annual lighting kWh B – Annual lighting kWh A) + Refrigeration savings due to reduced heat loss from lights.

Where:

kWh B	= total lighting run hours per year x wattage of baseline lighting / 1000
kWh A	= total lighting run hours per year x wattage of LED lighting / 1000

[29] Note: It is assumed that 0.2 of the saved energy escapes via conduction through the display case and does not have to be recaptured by the compressor.

$$\text{Refrigeration savings} = (LEDkWhsavings)\times\left(\frac{\frac{3{,}412\ Btu/h}{kW}}{\frac{12{,}000\ Btu/h}{ton}}\right)\times\left(\frac{kW}{ton}\right)$$

$$= (LEDkWhsavings)\times(0.28)\times(kW/ton)$$

Gross kW Savings = (Lighting kW B – Lighting kW A) + Refrigeration savings due to reduced heat loss from lights.

Where:

Lighting kW B = total lighting wattage of baseline lighting / 1000
Lighting kW A = total lighting wattage of LED lighting / 1000

$$\text{Refrigeration savings} = (LEDkWsavings)\times\left(\frac{\frac{3{,}412\ Btu/h}{kW}}{\frac{12{,}000\ Btu/h}{ton}}\right)\times\left(\frac{kW}{ton}\right)$$

$$= (LEDkWsavings)\times(0.28)\times kW/ton$$

kW/ton = 1.8 for coolers, 2.3 for freezers

Run hours per year adjusted for lighting controls; specify hours per day controlled off.

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 normal light output	38	76	38
6 foot LED case light	6 ft T12HO	46	112	66

Summary of Variables and Data Sources

Variable	Value	Notes
Baseline watts		Application. Use 2x LED watts as default
LED watts		Application
run hours		Application; default to 8760 if not known

Notes & 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.

Revision
0

High Performance Glazing

Description of Measure

High performance glazing system with reduced solar heat gain coefficient and U-value replacing single pane clear glass.

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = Glazing area (100 SF) × (ΔkW/100 SF) × CF_S

Gross Annual Energy Savings

ΔkWh = Glazing area (100 SF) × (ΔkWh/ 100 SF)

Δtherm = Glazing area (100 SF) × (Δtherm/ 100 SF)

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
Glazing area = Aperture area of glazing system in 100 SF
CF = coincidence factor
ΔkW/100 SF = electricity demand savings per 100 SF of glazing area
ΔkWh/100 SF = electricity consumption savings per 100 SF of glazing area
Δtherm/100 SF= gas consumption impact per 100 square foot of glazing.

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 industrial building types across seven different cities in NY are shown in Appendix F.

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

Recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline 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-deg F.

Compliance Efficiency from which Incentives are Calculated

The efficient glazing must have a solar heat gain coefficient of 0.40 or less and U-value of 0.57 Btu/hr-SF-deg F or less.

Operating Hours

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

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
Area		From application
ΔkW/100SF		Lookup by building type and city. See Appendix F.
CF_s	0.8	
Building type		From application

Notes & References

1. Glazing properties taken from ASHRAE Handbook of Fundamentals
2. High performance glass conforms to ASHRAE Standard 90.1 – 2007. Prescriptive requirements for metal frame windows assumed.

Revision Number

1

Window Film

Description of Measure

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 Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = Glazing area (100 SF) × (ΔkW/100 SF) × CF_S

Gross Annual Energy Savings

ΔkWh = Glazing area (100 SF) × (ΔkWh/ 100 SF)

Δtherm = Glazing area (100 SF) × (Δtherm/ 100 SF)

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
Glazing area = Aperture area of windows treated by window films in 100 SF
DF = demand diversity factor
CF = coincidence factor
ΔkW/100 SF = electricity demand savings per 100 SF of glazing area
ΔkWh/100 SF = electricity consumption savings per 100 SF of glazing area
Δtherm/100 SF= gas consumption impact per 100 square foot of glazing.

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.

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

Recommended values for the coincidence factors is shown below.

Parameter	Recommended Values
Coincidence factor	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-deg 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.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
Area		From application
ΔkWh/100SF		Lookup by building type and city
ΔkW/100SF		Lookup by building type and city
Δtherm/100SF		Lookup by building type and city
CF_s	0.8	
Building type		From application; use cross reference table as needed
HVAC type		Weighted average for built up systems as applicable

Notes & References

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

Revision Number

1

Cool Roof

Description of Measure

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 Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = kSF cool roof × (ΔkW/kSF) × CF_S

Gross Annual Energy Savings

ΔkWh = kSF cool roof × (ΔkWh/kSF)

Δtherm = kSF cool roof × (Δtherm/kSF)

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
kSF cool roof = thousand square feet of cool roof installed over a cooled space
DF = demand diversity factor
CF = coincidence factor
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 = gas consumption impact per thousand square foot of cool roof installed over a heated space.

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

Recommended values for the coincidence factors is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be roofing material with 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 compared to a standard roof with solar absorptance of 0.8.

Operating Hours

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

Non-Electric Benefits - Annual Fossil Fuel Savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
Area		From application
ΔkW/kSF		Lookup by building type and city. See Appendix I.
CF_s	0.8	
Building type		From application

Notes & References

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

Revision Number
1

Packaged Air Conditioners

Description of Measure

Rooftop and split system AC and heat pumps (cooling mode) in small commercial building applications.

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{12}{EER_{base}} - \frac{12}{EER_{ee}} \right) \times CF_S$$

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
SEER	= seasonal average energy efficiency ratio. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$EFLH_{cooling}$	= cooling equivalent full-load hours
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

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.

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

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

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 six different cities in NY are shown in Appendix G.

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

Recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

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

Baseline Performance Assumptions

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 IEER	11.1 EER
Unitary HP (3) phase	<65,000 3 Ph	13.0 IEER	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	10.5 IEER	10.4 EER
Unitary HP (3) phase	240,000 - 760,000	9.4 IEER	9.3 EER
Unitary HP (3) phase	>760,000	9.4 IEER	9.3 EER

Compliance Efficiency from which Incentives are Calculated

Based on program requirements.

Operating Hours

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

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application. Use 5 tons if unknown
EER_{base}		Lookup based on unit type and size
EER_{ee}		From application
$SEER_{base}$		Lookup based on unit type and size

$SEER_{ee}$		From application
CF_s	0.8	
$EFLH_{cool}$		Lookup based on building type and location
Type		From application
Building type		From application

Notes & 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 http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Revision Number

1

Packaged Air Source Heat Pumps

Description of Measure

A heat pump with improved heating season performance factor (HSPF). 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 Savings

$$\Delta kWh = units \times \frac{kBtuh_{out}}{unit} \times \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right) \times EFLH_{heat}$$

where:

ΔkWh = gross annual energy savings
units = number of heat pumps installed
$kBtuh_{out}$/unit = the nominal rating of the heating output capacity of the heat pump in kBtu/hr (including supplemental heaters)
HSPF = heating seasonal performance factor (Btu/watt-hr)
$EFLH_{heat}$ = heating equivalent full-load hours

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):

$$\Delta kWh = units \times \frac{kBtuh_{out}}{unit} \times \left(\frac{1}{COP_{base}} - \frac{1}{COP_{ee}} \right) \times \frac{EFLH}{3.413}$$

The HSPF is an estimate of the seasonal heating energy efficiency for an average US city. The COP is equal to the HSPF/3.413. Programs should use the manufacturers' rated HSPF or COP until data can be developed that are more appropriate for NY climates.

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

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

Nameplate capacity for heat pumps should include the full heating capacity of the heat pump system, including backup electric resistance heaters. Heating equivalent full load hours were calculated from a DOE-2.2 simulation of prototypical small commercial

buildings. The prototype building characteristics are described in Appendix A. The heating EFLH for commercial buildings in NY are shown in Appendix G.

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency 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 vary by building type and city. See table above.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated – electric heating system.

Summary of Variables and Data Sources

Variable	Value	Notes
$kBtuh_{out}$/unit		From application. Use 105 kBtu/hr if unknown.
$COP_{base,avg}$	COP or $HSPF_{base}$/3.413	Lookup based on system size
$HSPF_{base}$		Lookup based on system size
$COP_{ee,avg}$	COP or $HSPF_{base}$/3.413	From application
$HSPF_{ee}$		From application
$EFLH_{heat}$		Lookup based on building type and location

Building type		From application; use cross reference table as needed

Notes & References

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

Revision Number

1

Furnaces and Boilers

Description of Measure

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

Method for Calculating Energy Savings

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

where:

Δtherms	= gross annual gas savings
units	= number of units installed
kBtuh/unit	= the nominal heating input capacity in kBtu/hr
AFUE	= Average fuel utilization efficiency (0-100)
$EFLH_{heat}$	= heating equivalent full-load hours (relative to nameplate)

For larger units rated by thermal efficiency:

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

Where

$E_{t,base}$ = baseline unit thermal efficiency
$E_{t,ee}$ = efficient unit thermal efficiency

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

The ***average seasonal 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 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.

The ***thermal efficiency*** is an instantaneous full load efficiency, including jacket losses. Larger boilers should use the rated thermal efficiency until seasonal data for NY can be developed.

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

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

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

Baseline Efficiencies from which Savings are Calculated

The baseline efficiency ($\bar{\eta}_{base}$) is as follows: For new construction and replace on failure: minimum AFUE for new gas furnaces per NAECA is 78%. Common practice generally leads code, but there are no New York specific baseline data on baseline furnace efficiency available at this time. Baseline efficiency is 80% for hot water boilers and 75% for steam boilers.

Compliance Efficiency from which Incentives are Calculated

The furnace measure efficiency ($\bar{\eta}_{ee}$) is as follows:
ACEEE recommends two tiers: > 92% and > 95% AFUE

ACEEE recommends two tiers for hot water boilers: ≥85% for non-condensing applications and ≥ 90% for condensing applications. Steam boiler efficiency recommendations are: ≥ 82% AFUE with electronic ignition.

Operating Hours

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

Non-Gas Benefits - Annual Electric Savings

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

Summary of Variables and Data Sources

Variable	Value	Notes
$kBtuh_{in}$/unit		From application. Use 135 kBtu/hr if unknown
$AFUE_{base,}$	0.78 (furnaces) 0.80 (HW boilers) 0.75 (steam boilers)	
$AFUE_{ee}$		From application
$EFLH_{heat}$		Lookup based on building type and location
Building type		From application

Notes & References

1. Typical furnace sizes from National Grid participation data.

Revision Number

1

Programmable Setback Thermostat

Description of Measure

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

Method for Calculating Energy Savings

$$\Delta kWh = units \times \left[\frac{ton}{unit} \times \frac{12}{SEER} \times EFLH_{cool} \times ESF_{cool} + \frac{kBtuh_{out}}{unit} \times \frac{EFLH_{heat}}{HSPF} \times ESF_{heat} \right]$$

$$\Delta therms = units \times \frac{kBtuh_{in}}{unit} \times \frac{EFLH_{heat}}{100} \times ESF_{heat}$$

where:

ΔkWh = gross annual energy savings
Δtherms = gross annual gas 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 (Btu/watt-hour)
12 = conversion factor (kBtuh/ton)
ESF = energy savings factor
$kBtuh_{out}$/unit = the nominal rating of the heating output capacity of the heat pump in kBtu/hr (including supplemental heaters)
HSPF = heating seasonal performance factor (Btu/watt-hr), a measure of the seasonal average efficiency of the heat pump in the heating mode
$EFLH_{heat}$ = heating equivalent full-load hours
$EFLH_{cool}$ = cooling equivalent full-load hours

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 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.

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 setpoint 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.

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application or use 5 ton as default. Use 0 if no central cooling
$SEER_{base}$	10	
$EFLH_{cool}$		Vintage weighted average by city.

ESF_{cool}	0.09	
If heat pump:		
$kBtuh/unit_{out}$		From application or use 120 kBtu/hr as default
$HSPF_{base}$	6.8	
if furnace		
$kBtuh_{in}/unit$		From application or use 120 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 120 kBtu/hr as default. Use wt average of furnace and boiler if system type unknown.
$EFLH_{heat}$		Vintage weighted average by city.
ESF_{heat}	0.068	

Notes & 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.

Revision Number

1

Duct Insulation and Leakage Sealing

Description of Measure

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 Energy Savings

$$\Delta kWh = units \times \left[\frac{ton}{unit} \times \frac{12}{SEER} \times EFLH_{cool} \times \left[1 - \frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,ee}}\right]_{cool} + \frac{kBtuh_{out}}{unit} \times \frac{EFLH_{heat}}{HSPF} \times \left[1 - \frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,ee}}\right]_{heat}\right]$$

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

$$\Delta therms = units \times \frac{kBtuh_{in}}{unit} \times \frac{EFLH_{heat}}{100} \times \left[1 - \frac{\bar{\eta}_{dist,base}}{\bar{\eta}_{dist,ee}}\right]_{heat}$$

where:

Δ kWh	= gross annual electricity (kWh). savings
Δ kW	= gross peak demand (kW). savings
Δtherms	= gross annual gas savings
units	= number of units treated
$kBtuh_{in}$/unit	= the nominal input rating of the heating capacity of the furnace
$kBtuh_{out}$/unit	= the nominal output rating of the heating capacity of the heat pump
ton/unit	= the nominal rating of the cooling capacity of the air conditioner or heat pump in tons
SEER	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
HSPF	= average heating season efficiency of heat pump (Btu/watt-hour)
$\bar{\eta}_{dist}$	= duct system average seasonal efficiency
η_{dist}	= duct system efficiency under peak conditions
$EFLH_{cool}$	= cooling equivalent full load hours
$EFLH_{heat}$	= heating equivalent full load hours
CF	= coincidence factor

100 = conversion factor (kBtuh/therm)

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 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 ***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.

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 ($\overline{\eta}_{dist,base}$) 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 ($\overline{\eta}_{ee}$) for air conditioners, heat pumps and/or furnaces should be set according to the sections on this equipment above. The improved duct system efficiency ($\overline{\eta}_{dist,ee}$) 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.

Non-Gas Benefits - Annual Electric Savings

N/A – gas and electric benefits described above.

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
SEER	10	existing unit
	13	new construction
$\bar{\eta}_{dist,base}$		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.
$EFLH_{cool}$		Vintage weighted average by city.
EER_{base}	9.2	existing unit
	11.1	new unit
$\eta_{dist,base}$	$\bar{\eta}_{dist,base}$	
$\eta_{dist,ee}$	$\bar{\eta}_{dist,ee}$	
CF_s	0.8	
If heat pump:		
$kBtuh/unit_{out}$		From application
HSPF	6.8	existing unit
	8.1	new unit
if furnace		
$kBtuh_{in}/unit$		From application
$\bar{\eta}_{dist,base}$		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.
$EFLH_{heat}$		Vintage weighted average by city.

Notes & 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 Californi**a,*** 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.

Revision Number

1

Chillers

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

$$\Delta kW_S = units \times \frac{tons}{unit} \times \left(\frac{3.516}{COP_{base}} - \frac{3.516}{COP_{ee}} \right) \times CF_S$$

$$\Delta kWh = units \times \frac{tons}{unit} \times \left(\frac{3.516}{IPLV_{base}} - \frac{3.516}{IPLV_{ee}} \right) \times EFLH_{cooling}$$

where:

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

The rated full load ***COP*** at ARI conditions is used to define the efficiency under peak conditions. The ***IPLV*** as defined by ARI is used to define the seasonal average efficiency. These values represent average conditions across the US, and will be used until data specific to New York can be developed.

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

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

Cooling equivalent full load hours were calculated from a DOE-2.2 simulation of prototypical large office building. The prototype building characteristics are described in

Appendix A. The CLH for built-up HVAC systems in commercial buildings in various NY locations are shown in Appendix G.

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

Recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

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

Baseline Performance Assumptions

Equipment Category	Capacity Range	Baseline Efficiency (COP)	
		Average	Peak
Air Cooled Chiller	All	3.05	2.8
Water cooled Recip	All	5.05	4.2
Water cooled screw and scroll	< 150 tons	5.2	4.45
	150 – 300 tons	5.6	4.9
	> 300 tons	6.15	5.5
Water cooled centrifugal	< 150 tons	5.25	5.00
	150 – 300 tons	5.90	5.55
	> 300 tons	6.40	6.10

Compliance Efficiency from which Incentives are Calculated

Base on program eligibility criteria.

Operating Hours

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

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
tons		From application
COP_{base}		Lookup based on chiller type and size
COP_{ee}		From application
$IPLV_{base}$		Lookup based on chiller type and size
$IPLV_{ee}$		From application
CF_s	0.8	
$EFLH_{cool}$		Lookup by city building type and HVAC type
Chiller type	Air cooled, water cooled recip, Water cooled screw and scroll, Water cooled Centrifugal	From application
Building type		From application; use cross reference table as needed
HVAC type		From application

Notes & References

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

Revision Number

1

Cooling Tower

Description of Measure

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

Method for Calculating Energy Savings

Gross Annual Energy Savings

ΔkWh = cooling tons × (ΔkWh/ton)

Gross Summer Demand Savings

ΔkW = cooling tons × (ΔkW/ton)

where:

ΔkWh = gross annual energy savings
ΔkW = gross summer demand savings
cooling tons = size of cooling system retrofitted with a close approach tower
ΔkWh/ton = electricity consumption savings per ton of cooling system retrofitted with close approach tower
ΔkW/ton = summer peak demand savings per ton of cooling system retrofitted with close approach tower

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.

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

No therm impacts are anticipated from this measure.

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh/ton		Lookup based on building type, HVAC type and location
ΔkW/ton		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

Notes & References

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

Revision Number

1

Refrigerant Charge Correction

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

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

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

where:

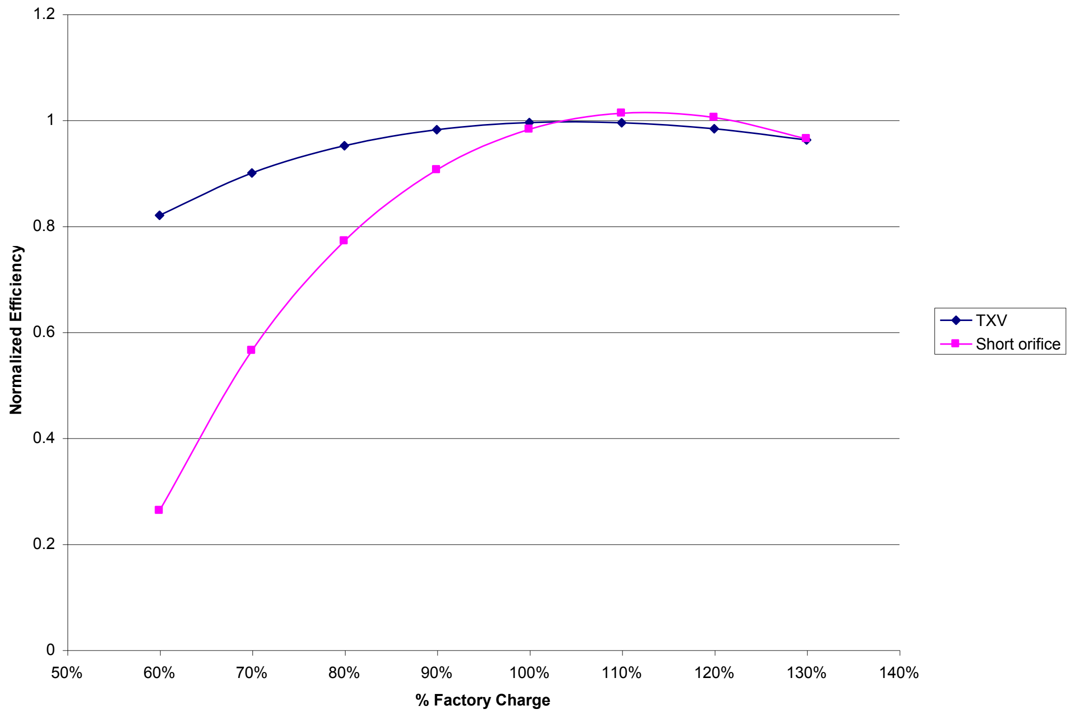
ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= the number of air conditioning units installed under the program
tons/unit	= tons of air conditioning per unit, based on nameplate data
SEER	= seasonal average energy efficiency ratio. (Btu/watt-hour)
EER	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$EFLH_{cooling}$	= cooling equivalent full-load hours
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

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

New Unit Efficiency Assumptions

Equipment Category	Capacity Range (Btu/hr)	Baseline Efficiency	
		Average	
Unitary A/C (1) phase	<65,000 1 Ph	13.0 SEER	Unitary A/C (1) phase
Unitary A/C (3) phase	<65,000 3 Ph	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 Ph	13.0 IEER	Unitary HP (1) phase
Unitary HP (3) phase	<65,000 3 Ph	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.

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

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

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

Cooling equivalent full load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. See Appendix G for cooling EFLH data for small commercial buildings.

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

Recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline (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.

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Notes & 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.

Revision Number

1

Air-Side Economizer

Description of Measure

Dual-enthalpy air-side economizer installed on packaged rooftop units serving small commercial buildings.

Method for Calculating Energy Savings

Gross Annual Energy Savings

$\Delta kWh = \text{cooling tons} \times (\Delta kWh/ton)$

where:

ΔkWh	= gross annual energy savings
cooling tons	= size of cooling system retrofitted with an economizer
$\Delta kWh/ton$	= electricity consumption savings per ton of cooling system retrofitted with an economizer

No peak demand savings are expected from this measure.

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:

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

No therm impacts are anticipated from this measure.

Summary of Variables and Data Sources

Variable	Value	Notes
ΔkWh/ton		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

Notes & References

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

Revision Number

1

Variable Frequency Drives

Description of Measure

Variable frequency drives applied to fans and pumps in commercial and industrial buildings. Applications covered in this section are:

1. AHU supply and return fans
2. CHW pumps
3. cooling tower fans
4. condenser water pumps
5. heating hot water pumps
6. HVAC exhaust fans
7. process exhaust or make-up air fans
8. process cooling pump
9. boiler draft fans
10. water supply or wastewater pumps
11. boiler feedwater pumps

Method for Calculating Summer Peak Demand and Energy Savings

$\Delta kW_S = hp \times (\Delta kW/hp) \times CF_S$
$\Delta kWh = hp \times (\Delta kWh/hp)$

where:

hp = size of motor controlled by VFD
kW/hp = peak demand savings from VFD per hp of motor controlled
kWh/hp = annual energy savings from VFD per hp of motor controlled
CF_s = coincidence factor

Units refers to the number of VSDs installed under the program.

Horsepower refers to the nameplate horsepower rating of the motor.

The ***unit energy and demand savings*** across several commercial building types are shown in Appendix J.

The ***coincidence factor*** 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.

Recommended value for the coincidence factors is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

The baseline system characteristics by application are as follows:

- Chilled water and hot water pumps: Variable volume, constant speed secondary pumping system 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.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
hp		From application
ΔkW/hp		Lookup by building type, city and VFD application
ΔkWh/hp		Lookup by building type, city and VFD application
CF_s	0.8	
Building type		From application

Notes & 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.

Revision Number
1

Water Heaters

Description of Measure

Efficient water heaters installed in whole-building applications.

Method for Calculating Energy Savings

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

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

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

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
Δtherm	= gross annual gas savings
units	= number of high efficiency water heaters installed under the program
UA_{base}	= overall heat loss coefficient of base water heater (Btu/hr-°F)
UA_{ee}	= overall heat loss coefficient of efficient water heater (Btu/hr-°F)
ΔT_s	= temperature difference between the stored hot water and the surrounding air (°F)
GPD	= average daily water consumption (gallons/day)
$\overline{\Delta T}_w$	= average difference between the cold inlet temperature and the hot water delivery temperature (°F)
$E_{t,base}$	= baseline water heater thermal efficiency
$E_{t,ee}$	= baseline water heater thermal efficiency
DF	= demand diversity factor
CF	= coincidence factor
8.33	= conversion factor (Btu/gallon-°F)
100,000	= conversion factor (Btu/therm)
365	= conversion factor (days/yr)

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 setpoint temperature. Water heater setpoint for commercial buildings is usually in the range of 150°F to 190°F. The water heater setpoint 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 setpoint 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 mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.3
NYC	56.5	62.5

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 Buillding 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 (Btu/hr-deg F)

Where:

SL = standby loss (Btu/hr)
70 = temperature difference associated with standby loss specification

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 0.80.

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.

Operating Hours

Water heater assumed to be available at all hours.

Non-Gas Benefits - Annual Electric Impacts

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

Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		Calc from SL_{base}
UA_{ee}		Calc from SL_{ee}
delta T_s	Tset - Tamb	
GPD		From application; defaults by building type shown in Table above.
delta T_w	Tset - Tmain	
Et_{base}	1.0 (elec)	
	0.8 (gas)	
Et_{ee}		From application
Tank volume		From application
T_{set}	140	Commercial WH setpoint consistent with GPD data
T_{amb}	65	
T_{mains}		Avg T_{mains} based on upstate or downstate
Capacity (Q)		From application (gas only)
SL_{base}		Calc from tank volume, capacity (gas only) and fuel type
SL_{ee}		From application
DF_s	1	

Notes & 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.

Revision Number

1

Indirect Water Heaters

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

Method for Calculating Energy Savings

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

where:

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

The ***ambient temperature difference*** between the water heat setpoint 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 setpoint 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 setpoint

temperature. Water heater setpoint for commercial buildings is usually in the range of 150°F to 190°F. The water heater setpoint 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 mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.3
NYC	56.5	62.5

The ***average daily hot water usage***, expressed in gallons per day across each commercial building type is described in the preceding section on standard tank-type water heaters.

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.

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.

Tank overall heat loss coefficient ***(UA)*** for the baseline water heater tank is calculated from the standby loss specification.

UA = SL/70 (Btu/hr-deg F)

where:

SL = standby loss (Btu/hr)
70 = temperature difference associated with standby loss specification

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

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

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-degF)
40	44	17	1 in foam	4.1
			2 in foam	2.1
80	44	24	1 in foam	6.1
			2 in foam	3.1
120	65	24	1 in foam	8.4
			2 in foam	5.4

Larger tank UA values are shown below.

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

The ***coincidence factor*** is used to account for the fact that not all water heaters in all buildings in the population are operating at full nameplate capacity at the time of the

system peak. The coincidence factor is defined as the average fraction of installed capacity of a population of water heaters that are operating at the time of system peak.

The recommended value for the coincidence factor is shown below.

Parameter	Recommended Values
Coincidence factor	0.8

Baseline Efficiencies from which Savings are Calculated

Baseline thermal efficiency for electric water heaters is assumed to be 1.0. Baseline thermal efficiency for gas water heaters is assumed to be 0.80. Baseline efficiency for existing boilers is 0.75.

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

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

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

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

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

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.

Summary of Variables and Data Sources

Variable	Value	Notes
UA_{base}		Calc from baseline water heater SL_{base} or lookup table based on tank volume and insulation thickness

Variable	Value	Notes
UA_{ee}		Calc from equation or lookup table based on tank volume and insulation thickness
delta T_s	Tset - Tamb	
GPD		Default to 78 gpd for single family residential, otherwise from application
delta T_w	Tset - Tmain	
Ec_{base}	0.97 (elec)	
	0.75 (gas)	
Ec_{ee}		From application
V		From application
T_{set}	130	
T_{amb}	65	
T_{mains}		Avg T_{mains} based on upstate or downstate
SL_{base}		From manufacturers' data

Notes & 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.

Revision Number

1

Low Flow Showerheads

Description of Measure

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.

Savings Estimation Approach – Method and Results[30]

Annual Energy Savings

Method

The savings estimations were derived through the following steps:

1. Develop estimate of annual gallons of water saved from the measure

Water Savings = ((GPM_{base} – GPM_{ee}) X (throttle factor) X (minutes/shower) X (#showers/day) X 365 (days/year))

Recommended values are shown in the table below.

Parameter	Value	Source
GPM_{base}	3.25	LBNL study
GPM_{ee}		Program tracking data on rebated showerhead flowrate
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

2. Calculate the amount of heat required to heat that much water

kWh Savings =((water savings x (temp to shower-temp to heater) x (8.3BTU per gallon) / (3414 Btu/kWh)) /water heater $efficiency_{elec}$

therm Savings =((water savings x (temp to shower-temp to heater) x (8.3BTU per gallon) / (100,000 Btu/therm)) /water heater $efficiency_{gas}$

Typical value for water temperature leaving the shower is 105°F. Inlet water temperature by location is shown below.

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

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

Standard assumptions for water heater efficiency are listed below.

Water Heater Type	Water heater efficiency
Electric	0.97
Gas	0.75

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}		From application
GPM_{base}	3.25	
Throttle factor	0.75	
Min/shower	8	
Shower/day		From application; varies across building types
T_{shower}	105	
T_{mains}		Avg T_{mains} based on upstate or downstate
Water heater effic	0.97	Electric
	0.75	Gas

Notes & References

1. Average hot water use per person taken from: Lutz, James D., Liu, Xiaomin, McMahon, James E., Dunham, Camilla, Shown, Leslie J.McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996.
2. Average annual outdoor temperature taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE-2.2 weather data statistics package. www.nrel.gov
3. Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.

Revision Number

1

Faucet Aerators

Description of Measure

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.

Savings Estimation Approach – Method and Results[31]
Annual Energy Savings

Method
The savings estimations were derived through the following steps:

1. Develop estimate of annual gallons of water saved from the measure

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

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.[32]

Water Savings (Gallons/year)

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

2. Calculate energy savings

kWh Savings =((water savings x (temp faucet-temp to heater) x (8.3BTU per gallon) / (3413Btu/kWh)) /water heater efficiency$_{elec}$

therm Savings =((water savings x (temp faucet-temp to heater) x (8.3BTU per gallon) / (100,000Btu/therm)) /water heater efficiency$_{gas}$

[31]This methodology is derived from CL&P and UI Program Savings Documentation for 2008 Program Year, pp. 157-158.
[32] Federal Energy Management Program "Domestic Water Conservation Technologies" at http://www1.eere.energy.gov/femp/pdfs/22799.pdf and other sources.

Typical value for water temperature leaving the faucet is 80 degrees F. Inlet water temperature by location is shown below.

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

Standard assumptions for water heater efficiency are listed below.

Water Heater Type	Water heater efficiency
Electric	0.97
Gas	0.75

Summary of Variables and Data Sources

Variable	Value	Notes
GPM_{ee}	2.2	
GPM_{base}	1.5	
Duration (minutes)	0.5	
Uses/day	30	
Days per year	260	Average days of operation for businesses
T_{faucet}	80	
T_{mains}		Avg T_{mains} based on upstate or downstate
Water heater effic	0.97	Electric
	0.75	Gas

Notes & 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. http://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.

Revision Number
1

Evaporator Fan Controls

Description of Measure

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

Savings Estimation Approach

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

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

$\Delta kWh = \Delta kWh\ EF + \Delta kWh\ RH + \Delta kWh\ EC$

where:

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

$\Delta kWh\ EF = kW_{fan} * FLH_{fan} * F_{off}$

where:

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

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

where:

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

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

where:

kW_{comp} = Compressor kW
= $V_{comp} * A_{comp} * (phase_{comp})^{0.5} * PF_{comp}$
V_{comp} = Compressor nameplate volts
A_{comp} = Compressor nameplate amps
Phase = number of phases (1 or 3)
PF_{comp} = power factor for compressor
FLH_s = Compressor summer FLH
= $Cycle_{summer} * hr_{summer}$
FLH_w = Compressor winter FLH
= $Cycle_{winter} * hr_{winter}$
F_{off} = Fraction of time that Evaporator Fan is turned off.
F_{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)

ΔkW = $kW_{fan} * DF$

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

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

<u>Notes & References</u>

1. Diversity factor taken from “New England Power Service Co. study of Economizers and Evaporator Fan Controls”, HEC, June 28, 1996.

Revision Number
1

Efficient Air-Cooled Refrigeration Condenser

Description of Measure

Install an efficient, close approach air-cooled refrigeration system condenser. This measure savings energy by reducing condensing temperatures and improving the efficiency of the condenser fan system.

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = compressor tons × (ΔkW/ton) × CF_S

Gross Annual Energy Savings

ΔkWh = compressor tons × (ΔkWh/ton)

where:

ΔkW = gross summer peak demand savings
ΔkWh = gross annual energy savings
compressor tons = refrigeration system compressor capacity
ΔkWh/ton = electricity consumption savings per ton of compressor capacity
DF = demand diversity factor
CF = coincidence factor

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 five 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
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

The ***coincidence factor*** is used to account for the fact that not all condensers 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 condensers that are operating at the time of the system peak.

Recommended value for the coincidence factors is shown below.

Parameter	Recommended Values
Coincidence factor	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 active 24/7.

Non-Electric Benefits - Annual Fossil Fuel Savings

No therm impacts anticipated for this measure.

Summary of Variables and Data Sources

Variable	Value	Notes
Tons		From application
ΔkW/ton		Lookup based on upstate average or NYC
ΔkWh/ton		Lookup based on upstate average or NYC
CF_s	1.0	

Notes & 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

http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Revision Number
1

Anti-Sweat Heater Controls

Description of Measure

Anti-sweat heater controls for glass reach-in doors on grocery store freezer cases.

Method for Calculating Summer Peak Demand and Energy Savings

Cooler Doors

Gross kWh Savings = Pre kWh usage – Post kWh usage
$(kW_{DH} * 8{,}760) – (60\% * kW_{DH} * 3{,}760)$
Where:

- kW_{DH} = Total demand (kW) of the cooler door heaters, calculated using nameplate Volts and Amps.
- 8,760 = Annual run hours of cooler door heaters before controls
- 60% = Percent of Total Power at which cooler door heaters run after controls giving minimum reduction. Estimated by NRM based on their experience of monitoring the equipment at various sites.
- 3,760 = Number of hours at which cooler door heaters run at reduced power level of 40%

Gross kW Savings = Cooler Door Heater Demand * 74% * 75%
Where:

- Door Heater Demand = Total demand of cooler door heaters, calculated using nameplate Volts and Amps.
- 74% = cooler door heaters off time. This value is an estimate by National Resource Management based on hundreds of downloads of hours of use data from door heater controllers. This is supported by a 3rd party study conducted by Select Energy for NSTAR, "Cooler Control Measure Impact Spreadsheet Users' Manual", Page 5, March 9, 2004.

- 75% = Estimate of an additional adjustment factor to account for diversity and coincidence at time of peak which is not captured in the above factor.

Freezer Doors

Gross kWh Savings = Pre kWh usage – Post kWh usage
$= (kW_{DH} * 8{,}760) – ((40\% * kW_{DH} * 4{,}000) + (kW_{DH} * 4{,}760 * .65))$
Where:

- kW_{DH} = Total demand (kW) of the door heaters, calculated using nameplate Volts and Amps.
- 8,760 = Annual run hours of door heater before controls

40% = Percent of Total Power at which door heaters run after controls giving maximum reduction. Estimated by NRM based on their experience of monitoring the equipment at various sites.
4,000 = Number of hours at which door heaters run at reduced power level of 40%
4,760 = Number of hours at which door heaters run at reduced power level of 65%
65% = Percent of Total Power at which door heaters run after controls giving minimum reduction. Estimated by NRM based on their experience of monitoring the equipment at various sites.

Gross kW Savings = Door Heater Demand * 46% * 75%
Where:
Door Heater Demand = Total demand of door heaters, calculated using nameplate Volts and Amps.
46% = Door heater off time. This value is an estimate by National Resource Management (SBS Cooler Measures Vendor) based on hundreds of downloads of hours of use data from door heater controllers.
75% = An additional adjustment factor to account for diversity and coincidence at time of peak which is not captured in the above factor.

Baseline Efficiencies from which Savings are Calculated

The baseline condition is assumed to be no anti-sweat heater controls.

Compliance Efficiency from which Incentives are Calculated

TBD

Operating Hours

The control system is assumed to be active 24/7.

Non-Electric Benefits - Annual Fossil Fuel Savings

Minor space heating interactions with anti-sweat heater controls will be ignored.

Notes & 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 http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Revision Number
1

Refrigerated Case Night Covers

Description of Measure

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%.

Method for Calculating Energy Savings

Gross Annual Energy Savings

S = W*H*F
S = Savings, kWh per year.
W = Width of the opening that the covers protect, ft.
H = Hours per year the covers are in use.
F = Savings factor based on the temperature of the case, kW/ft

There are no demand savings for this measure because the covers will not be in use during the peak period.

The following savings factor values are recommended. These factors are based on a study by Southern California Edison[33].

Low temperature (-35°F to -5°F) = 0.1 kW/ft
Medium temperature (0°F to 30°F) = 0.06 kW/ft
High temperature (35°F to 55°F) = 0.04 kW/ft

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.

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[33] "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.

Notes & 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 http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf

Revision Number

1

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

EC Motor retrofits in Walk-in Coolers and Freezers

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

Where:

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

Where each component is calculated in the following manner:

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

Where:

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

And:

$kWh\ Savings_{RH}$ - (Savings due to reduced heat from fan motors) =

$kWh\ Savings_{EF} * 0.28 * 1.6$

Where:

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

Refrigerated Case Motor Replacement

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

Where:

kW A = metered load of case motors

53% = energy reduction if a shaded pole motors is being replaced. Based on numerous pre and post meterings conducted by NRM

29% = energy reduction if a PSC motor is being replaced. Based on numerous pre and post meterings conducted by NRM

8,500 = average runtime of case motors

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

$\text{kWh Savings}_{CM} * 0.28 * 1.6$

Where:

kWh SavingsCM = Savings due to Case Motors being replaced (see above).

0.28 = unit conversion between kW and tons, see LED Lighting Calculation for derivation of value

1.6 = Efficiency of typical refrigeration system, units are kW/ton

Revision Number

1

Vending Machine Central Controls

Description of Measure

This measure is essentially an approach for controlling the operations of vending machines so that they are only operating when needed. The controls are typically 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.

Savings Estimation Approach

Gross kWh Savings =
(Demand of Novelty Cooler) * ((0.45 * (hrs off/day * 91 days)) + (0.50 * (hrs off/day * 274 days)))

Where:

Demand of Novelty Cooler = Total demand of all Novelty Coolers, based on nameplate Volts and Amps, Phase, and Power Factor .
0.45 = Duty cycle during winter month nights, based on vendor estimates
Hrs off/day = 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).
91 days = Number of days in winter months
0.50 = Duty cycle during non-winter month nights, based on vendor estimates
274 days = Number of days in non-winter months.
Power Factor = 0.85, based on NRM's experience.

Revision Number

1

Air Compressor Upgrade

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = compressor hp × (ΔkW/hp) × CF_S

Gross Annual Energy Savings

ΔkWh = compressor hp × (ΔkW/hp) × hr

where:

ΔkW = gross summer peak demand savings
ΔkWh = gross annual energy savings
compressor hp = air compressor horsepower
ΔkW/hp = air compressor kW reduction per hp
Hr = annual operating hours of air compressor
CF = coincidence factor

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

Baseline Efficiencies from which Savings are Calculated

Typical modulating compressor with blowdown.

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
Compressor hp		From application
ΔkW/hp		Lookup based on compressor size and load control strategy
hours		From application
CF_s	0.80	

Notes & References

Revision Number

1

Compressed Air Engineered Nozzle

Description of Measure

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 Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

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

Gross Annual Energy Savings

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

where:

ΔkW	= gross summer peak demand savings
ΔkWh	= gross annual energy savings
$FLOW_{baseline}$	= 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 of air compressor
CF	= coincidence factor

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

Baseline Efficiencies from which Savings are Calculated

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

Compliance Efficiency from which Incentives are Calculated

Typical modulating compressor with blowdown 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.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

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	
CF_s	0.75	
hr		From application

Notes & References

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

Revision Number

1

No Loss Drain

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = no. drains × (ΔkW/drain) × CF_S

Gross Annual Energy Savings

ΔkWh = no. drains × (ΔkW/drain) × hr

where:

ΔkW = gross summer peak demand savings
ΔkWh = gross annual energy savings
compressor hp = air compressor horsepower
ΔkW/hp = air compressor kW reduction per hp
Hr = annual operating hours of air compressor
CF = coincidence factor

Measure	ΔkW/unit
No loss drain	0. 3 kW / drain

Baseline Efficiencies from which Savings are Calculated

Electronic solenoid / timed drains.

Compliance Efficiency from which Incentives are Calculated

No loss drain must be used with a Load/NoLoad with appropriately sized storage, VSD or variable displacement compressor.

Operating Hours

Varies by application.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
Number of drains		From application
ΔkW/drain	0.3	National Grid recommended value
hours		From application
CF_s	0.80	

Notes & References

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.

Revision Number

1

Refrigerated Air Dryer

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

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

Gross Annual Energy Savings

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

where:

ΔkW	= gross summer peak demand savings
ΔkWh	= gross annual energy savings
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

Dryer Capacity (CFM_{dryer})	ΔkW/CFM
<100	0.005
≥ 100 and < 200	0.004
≥ 200 and < 300	0.003
≥ 300 and < 400	0.003
≥ 400	0.003

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.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Variable	Value	Notes
CFM_{dryer}		From application
$\Delta kW/cfm$	Lookup based on dryer size	From MA TRM
hours		From application
CF_s	0.80	

Notes & References

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

Revision Number

1

Motors

Description of Measure

NEMA premium efficiency motors replacing standard efficiency motors in commercial and industrial applications.

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

$$\Delta kW_S = units \times 0.746 \times \left[\frac{hp_{base} \times RLF_{base}}{\eta_{base}} - \frac{hp_{ee} \times RLF_{ee}}{\eta_{ee}} \right] \times DF_S \times CF_S$$

Gross Annual Energy Savings

$$\Delta kWh = units \times 0.746 \times \left[\frac{hp_{base} \times RLF_{base}}{\eta_{base}} - \frac{hp_{ee} \times RLF_{ee}}{\eta_{ee}} \right] \times FLH$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= number of motors installed under the program
η_{base}	= efficiency of base motor
η_{ee}	= efficiency of high-efficiency motor
hp_{base}	= horsepower of base motor (hp)
hp_{ee}	= horsepower of high-efficiency motor (hp)
RLF_{base}	= rated load factor for the base motor
RLF_{ee}	= rated load factor for the high-efficiency motor
FLH	= full-load hours
DF	= demand diversity factor
CF	= coincidence factor
0.746	= conversion factor (kW/hp)

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.

$$\left(RLF \times hp\right)_{base} = \left(RLF \times hp\right)_{ee}$$

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.

Note: 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.

The ***coincidence factor*** is used to account for the fact that not all motors 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 that are operating at the time of the system peak.

Recommended value for the coincidence factor is shown below.

Parameter	**Recommended Values**
Coincidence factor	0.8

These values should be used as default values until better data are identified or developed through EM&V studies.

<u>Baseline Efficiencies from which Savings are Calculated</u>

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.

<u>Compliance Efficiency from which Incentives are Calculated</u>

Must exceed new Federal standards.

Operating Hours

Facility Type	Fan Motor Hours	CHWP & Cooling Towers	Heating Pumps
Auto Related	4,056	1,878	6,000
Bakery	2,854	1,445	6,000
Banks, Financial Centers	3,748	1,767	6,000
Church	1,955	1,121	6,000
College - Cafeteria	6,376	2,713	6,000
College - Classes/Administrative	2,586	1,348	6,000
College - Dormitory	3,066	1,521	6,000
Commercial Condos	4,055	1,877	6,000
Convenience Stores	6,376	2,713	6,000
Convention Center	1,954	1,121	6,000
Court House	3,748	1,767	6,000
Dining: Bar Lounge/Leisure	4,182	1,923	6,000
Dining: Cafeteria / Fast Food	6,456	2,742	6,000
Dining: Family	4,182	1,923	6,000
Entertainment	1,952	1,120	6,000
Exercise Center	5,836	2,518	6,000
Fast Food Restaurants	6,376	2,713	6,000
Fire Station (Unmanned)	1,953	1,121	6,000
Food Stores	4,055	1,877	6,000
Gymnasium	2,586	1,348	6,000
Hospitals	7,674	3,180	6,000
Hospitals / Health Care	7,666	3,177	6,000
Industrial - 1 Shift	2,857	1,446	6,000
Industrial - 2 Shift	4,730	2,120	6,000
Industrial - 3 Shift	6,631	2,805	6,000
Laundromats	4,056	1,878	6,000
Library	3,748	1,767	6,000
Light Manufacturers	2,857	1,446	6,000
Lodging (Hotels/Motels)	3,064	1,521	6,000
Mall Concourse	4,833	2,157	6,000
Manufacturing Facility	2,857	1,446	6,000
Medical Offices	3,748	1,767	6,000
Motion Picture Theatre	1,954	1,121	6,000
Multi-Family (Common Areas)	7,665	3,177	6,000
Museum	3,748	1,767	6,000
Nursing Homes	5,840	2,520	6,000
Office (General Office Types)	3,748	1,767	6,000
Office/Retail	3,748	1,767	6,000
Parking Garages & Lots	4,368	1,990	6,000
Penitentiary	5,477	2,389	6,000
Performing Arts Theatre	2,586	1,348	6,000

Facility Type	Fan Motor Hours	CHWP & Cooling Towers	Heating Pumps
Police / Fire Stations (24 Hr)	7,665	3,177	6,000
Post Office	3,748	1,767	6,000
Pump Stations	1,949	1,119	6,000
Refrigerated Warehouse	2,602	1,354	6,000
Religious Building	1,955	1,121	6,000
Residential (Except Nursing Homes)	3,066	1,521	6,000
Restaurants	4,182	1,923	6,000
Retail	4,057	1,878	6,000
School / University	2,187	1,205	6,000
Schools (Jr./Sr. High)	2,187	1,205	6,000
Schools (Preschool/Elementary)	2,187	1,205	6,000
Schools (Technical/Vocational)	2,187	1,205	6,000
Small Services	3,750	1,768	6,000
Sports Arena	1,954	1,121	6,000
Town Hall	3,748	1,767	6,000
Transportation	6,456	2,742	6,000
Warehouse (Not Refrigerated)	2,602	1,354	6,000
Waste Water Treatment Plant	6,631	2,805	6,000
Workshop	3,750	1,768	6,000

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated.

Summary of Variables and Data Sources

Notes & 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.

Revision Number
1

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 on the basis of 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.

Four Types of EEPS/SBC Custom Measures

For the EEPS and SBC energy efficiency programs custom measures includes the following four categories:

1. 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.

2. Measures 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.

3. 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.

4. 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 than 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 (HPwES). 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

Issue	Criteria
	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.
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

Issue	Criteria
	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.

Issue	Criteria
PA notification requirements	Protocols for informing a PA representative of issues with consultant services quality should be described.

APPENDIX A. PROTOTYPICAL BUILDING DESCRIPTIONS

Residential Building Prototypes

Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[34] study, with adjustments made for local building practices and climate.

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

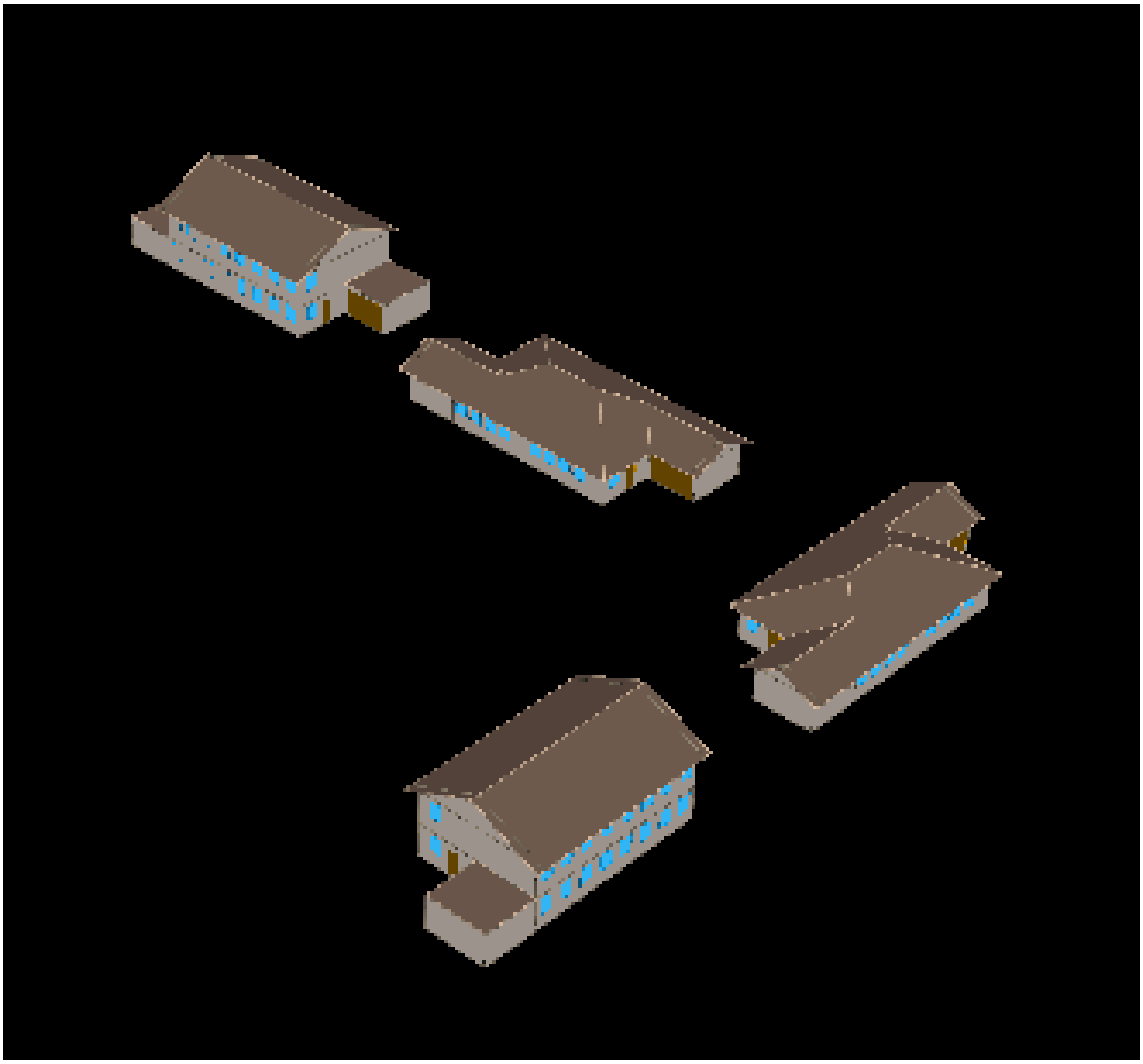
1. Old, poorly insulated buildings constructed before 1979, before the NY State Energy Code went into effect. This vintage is referred to as the "old" vintage.
2. Existing, average insulated buildings conforming to 1980s era building codes. This vintage is referred to as the "average" vintage.
3. New construction conforming to the 2007 Energy Conservation Code of New York State for residential buildings. This vintage is referred to as the "new" vintage.

Single Family Residential Prototype

The single family "model" in fact contains 4 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 4 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures.

A sketch of the single family residential prototype buildings is shown below.

[34] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf



Computer rendering of single family residential building prototypical DOE-2 model.

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

Characteristic	Value
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	Baseline SEER = 13
Thermostat setpoints	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 setpoint 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.

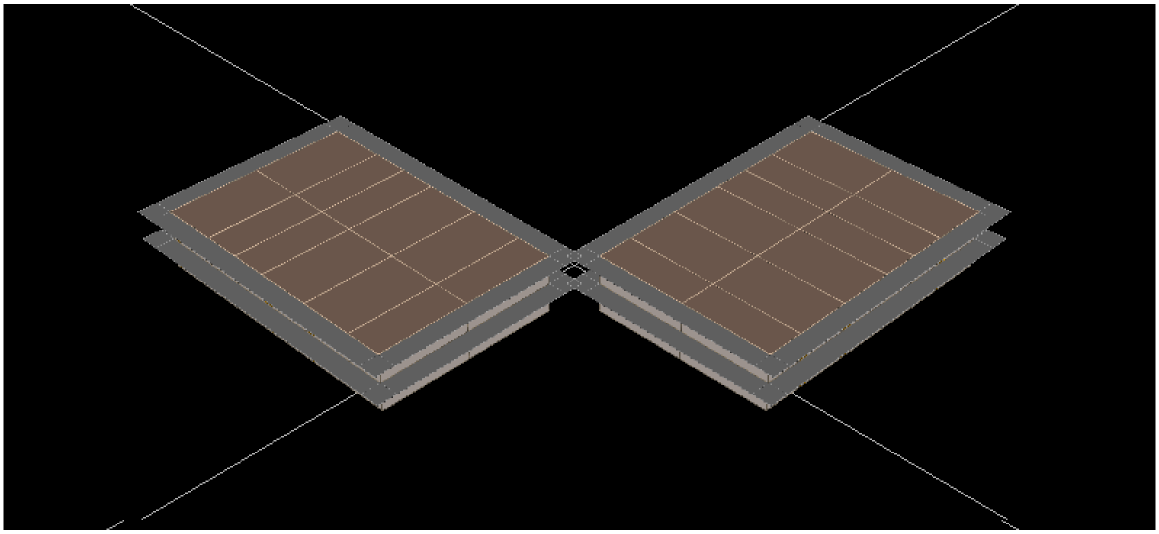
Multi-family Low-Rise

The low-rise prototype "model" in fact contains 2 separate buildings. Each version of the buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these 2 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures.

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

1. Old, poorly insulated buildings constructed before 1979, when the NY State Energy Code first went into effect. This vintage is referred to as the "old" vintage.
2. Existing, average insulated buildings conforming to 1980s era building codes. This vintage is referred to as the "average" vintage.
3. New construction conforming to the 2007 Energy Conservation Code of New York State for residential buildings. This vintage is referred to as the "new" vintage.

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	Three vintages simulated – old poorly insulated buildings, existing average insulated buildings and new buildings
Conditioned floor area	949 SF per unit; 6 units per floor, 2 floors per building, 11,388 SF total.
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 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
HVAC system types	1. Split system AC with 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. Gas 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 AFUE = 78
Thermostat setpoints	Heating: 70°F with setback to 67°F Cooling: 75°F with setup to 78°F
Duct location	In attic and plenum space between first and second floors. PTACs and PTHPs have no duct work.
Duct surface area	256 SF supply, 47 SF return per system
Duct insulation	Uninsulated

Characteristic	Value
Duct leakage	20% of fan flow total leakage, evenly split between supply and return.
Natural ventilation	Allowed during cooling season when cooling setpoint exceeded and outdoor temperature < 65°F. 3 air changes per hour

Wall and Ceiling Insulation Levels

The assumed values for wall and ceiling by vintage are below.

Wall Insulation R-Value Assumptions by Vintage

Vintage	Assumed R-value of insulated wall	Notes
Older, poorly insulated	7	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	0.68	0.77	Double pane clear
New construction	0.28	.49	Double low e per code

Infiltration

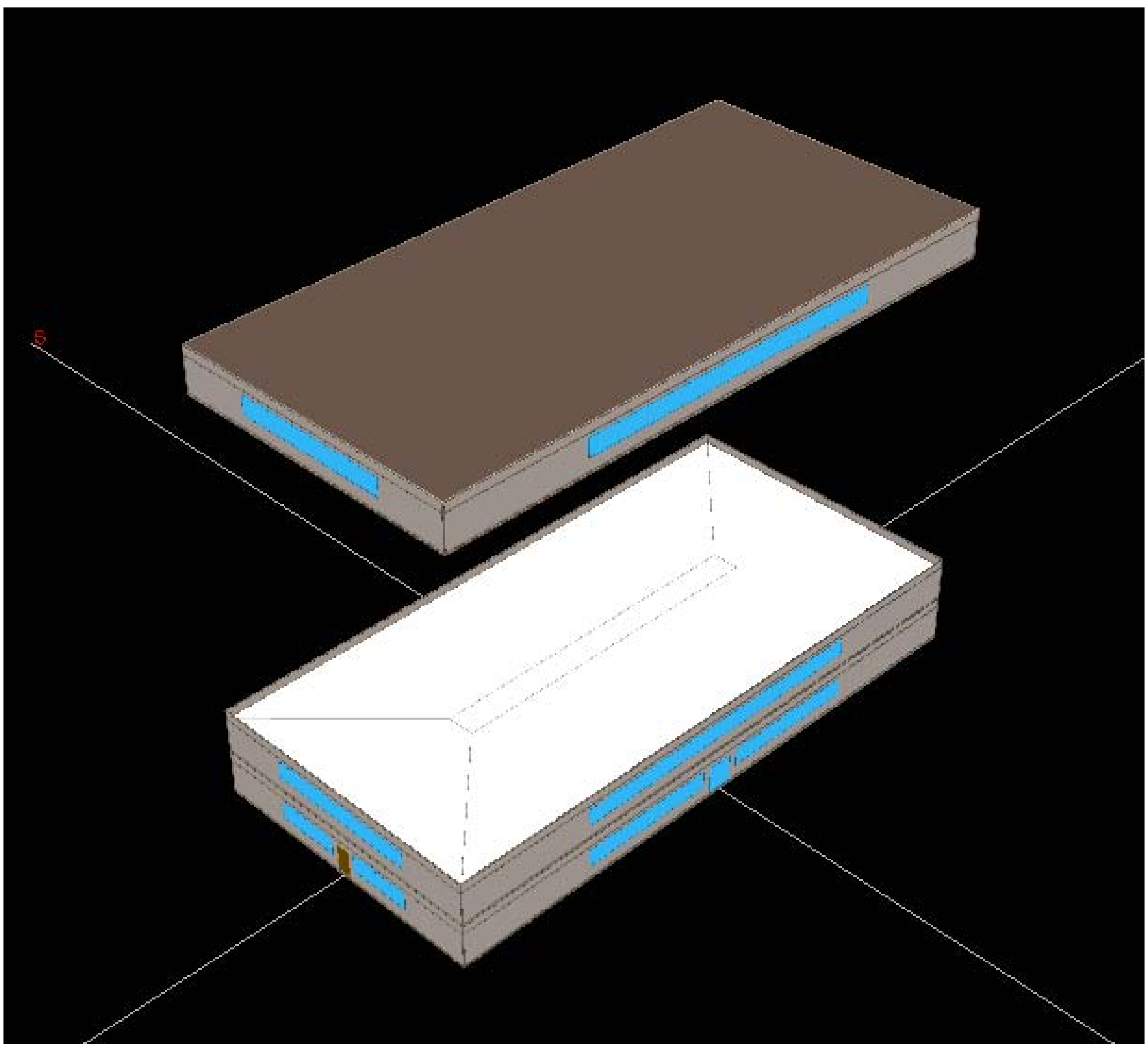
Infiltration rate assumptions were set by vintage as shown below.

Infiltration Rate Assumptions by Vintage

Vintage	Assumed infiltration rate	Notes
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 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	Three vintages simulated – old poorly insulated buildings, existing average insulated buildings and new buildings
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	Four pipe fan coil with air cooled electric chiller and gas hot water boiler
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	Chiller: COP = 3.9 Boiler: Thermal efficiency = 78%
Thermostat setpoints	Heating: 70°F with setback to 67°F 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
Older, poorly insulated	7	No insulation; air gap resistance only
Existing, average insulation	11	Same as low rise
New construction	19	Code

Roof Insulation R-Value Assumptions by Vintage

Vintage	Assumed R-value of insulated ceiling	Notes
Older, poorly insulated	11	Same as low rise
Existing, average insulation	19	Same as low rise
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	0.68	0.77	Double pane clear
New construction	0.28	.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
Older, poorly insulated	1 ACH	Same as low rise
Existing, average insulation	0.5 ACH	Same as low rise
New construction	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)[35] 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.

Assembly

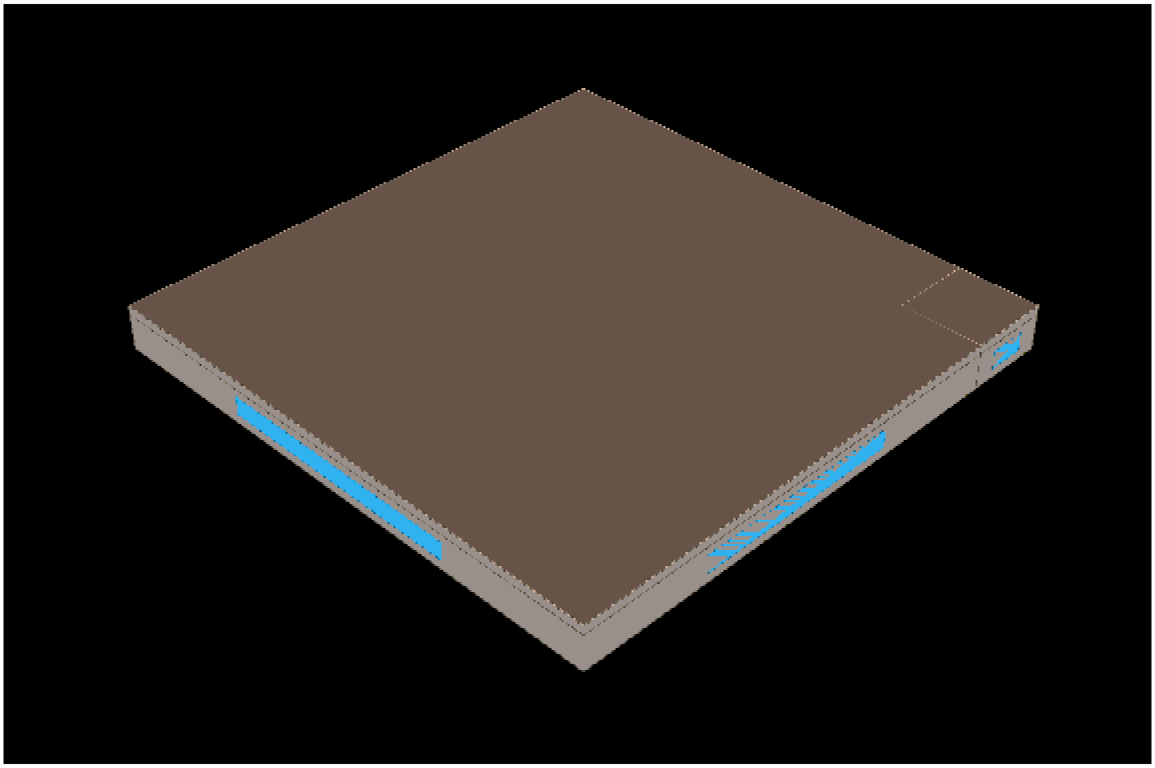
A prototypical building energy simulation model for an assembly building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the prototype is shown below.

[35] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf



Assembly Building Rendering

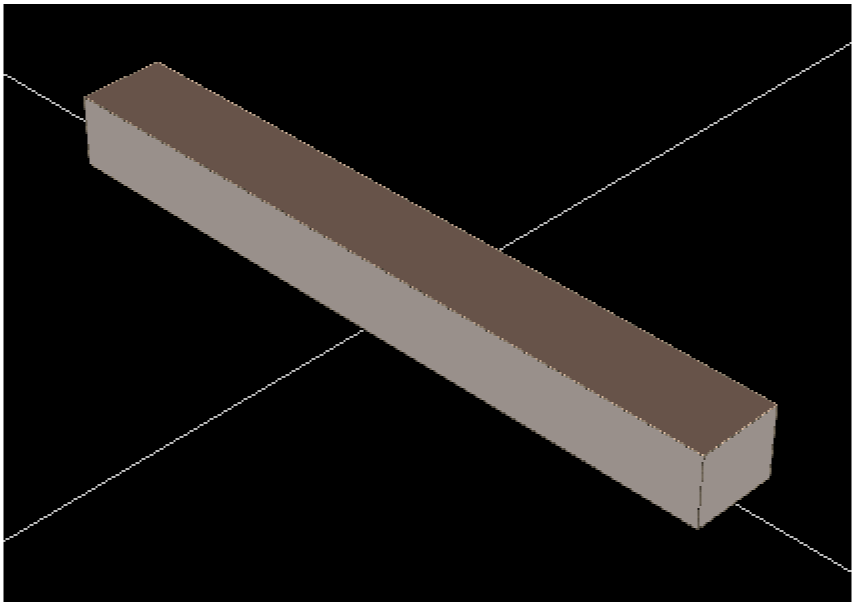
Auto Repair

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 setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown below.



Auto Repair Building Rendering

Big Box Retail

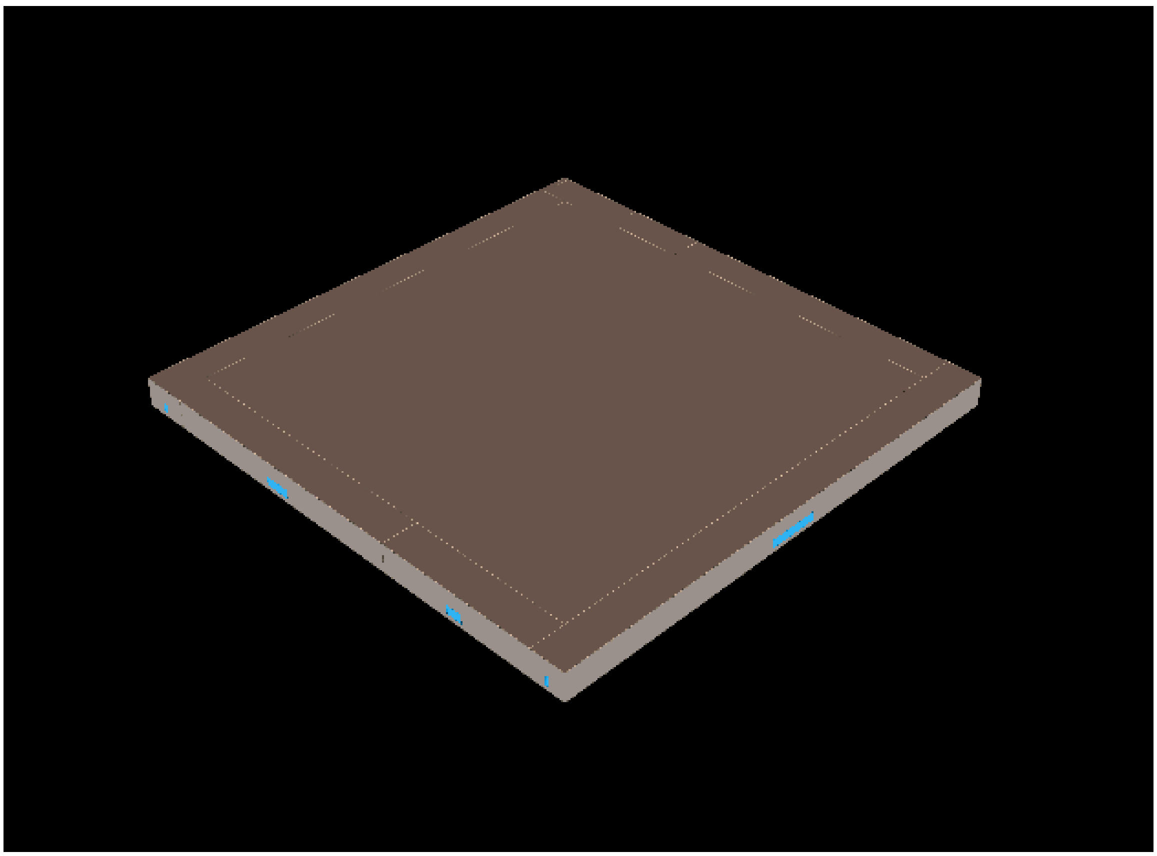
A prototypical building energy simulation model for a big box retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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

Characteristic	Value
	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 setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the prototype is shown below.



Big Box Retail Building Rendering

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.

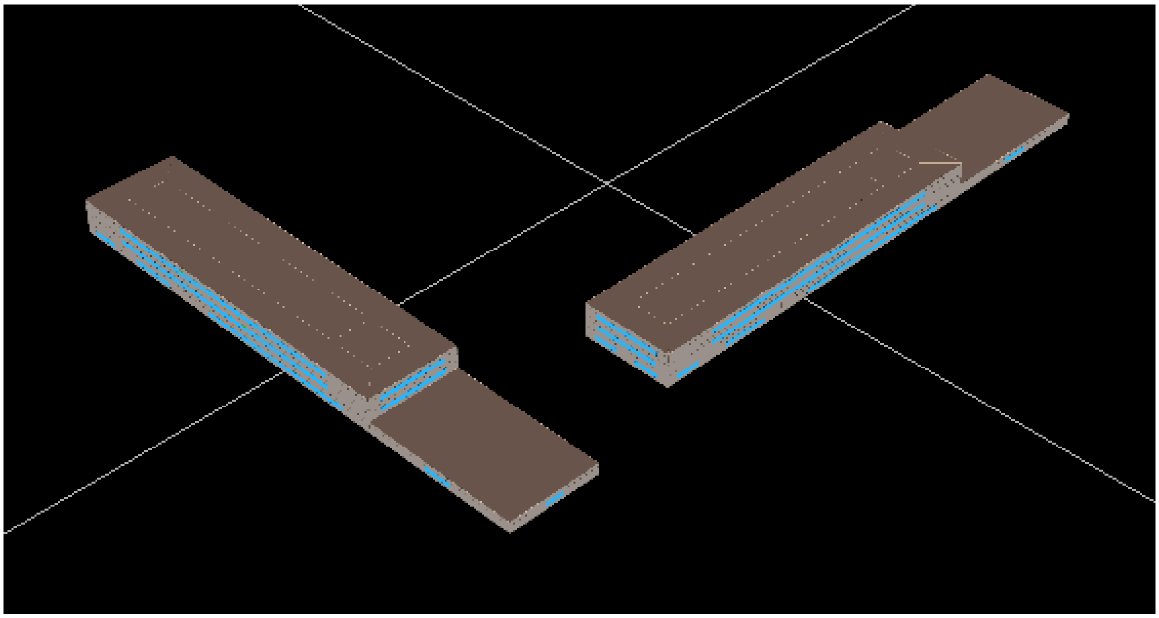
Community College Prototype Building Description

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 setpoints	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 deg F setpoint
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 deg F setpoint

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 prototype is shown below.



Community College Rendering

Dormitory

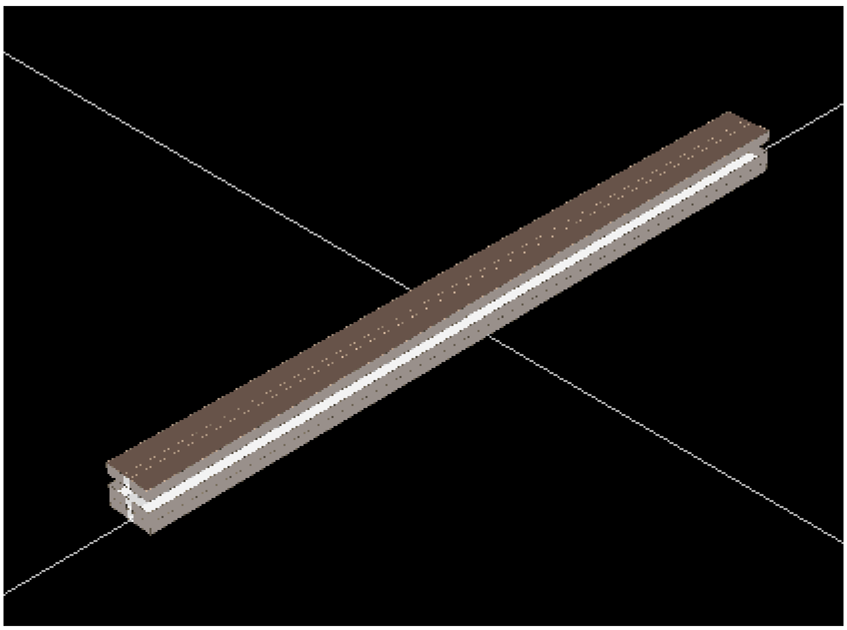
A prototypical building energy simulation model for a university dormitory was developed using the DOE-2.2 building energy simulation program. The dormitory building was extracted from the DEER university prototype and modeled separately. The model consists of two identical buildings oriented 90 degrees 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 setpoints	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

A computer-generated sketch of the 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.



Dormitory Building Rendering

Elementary School

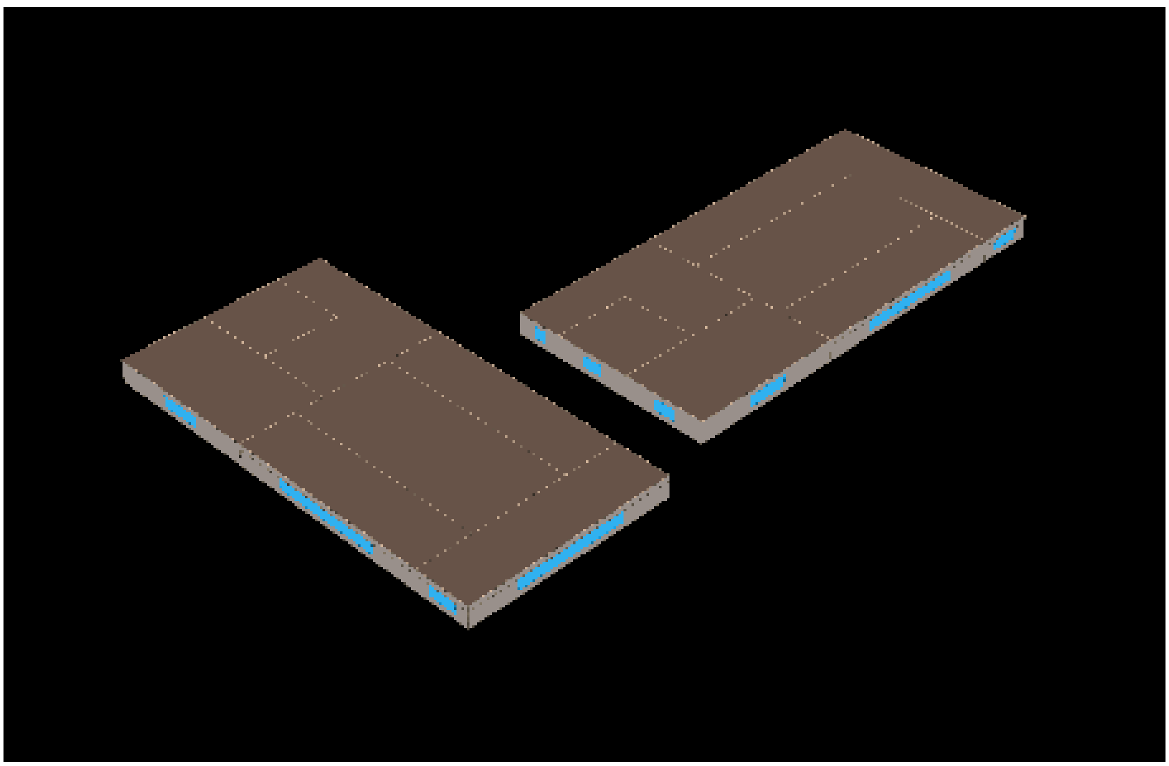
A prototypical building energy simulation model for an elementary school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of two identical buildings oriented in two different directions. The 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

Characteristic	Value
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 setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the prototype is shown below.



Elementary School Building Rendering

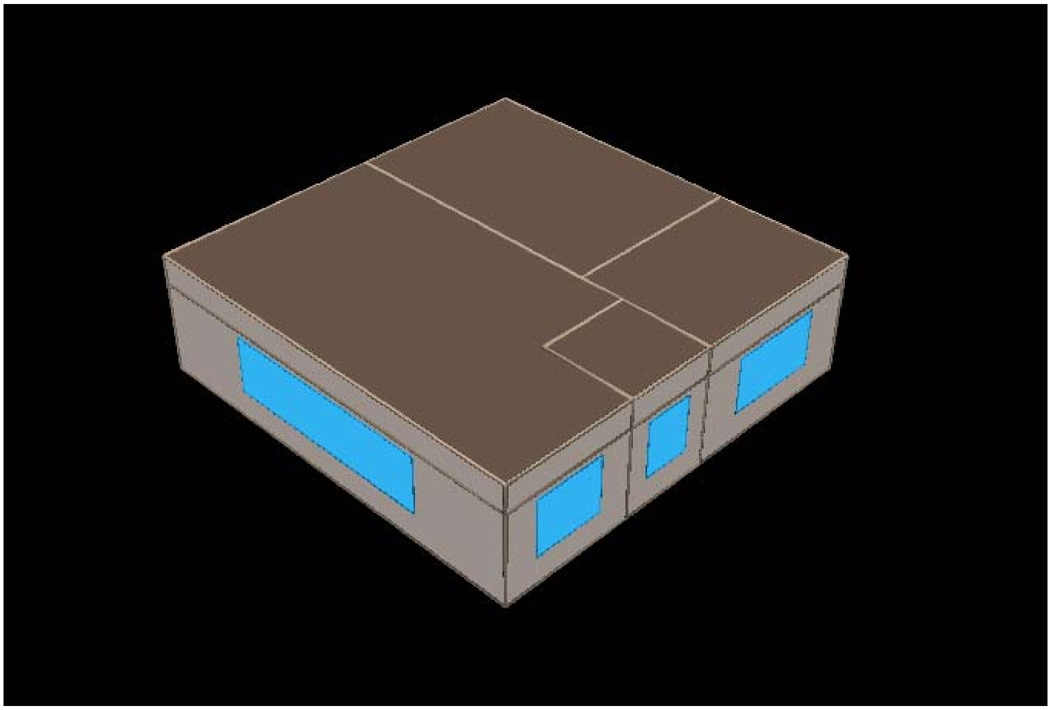
Fast Food Restaurant

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 1000 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 setpoints	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

A computer-generated sketch of the prototype is shown below.



Fast Food Restaurant Building Rendering

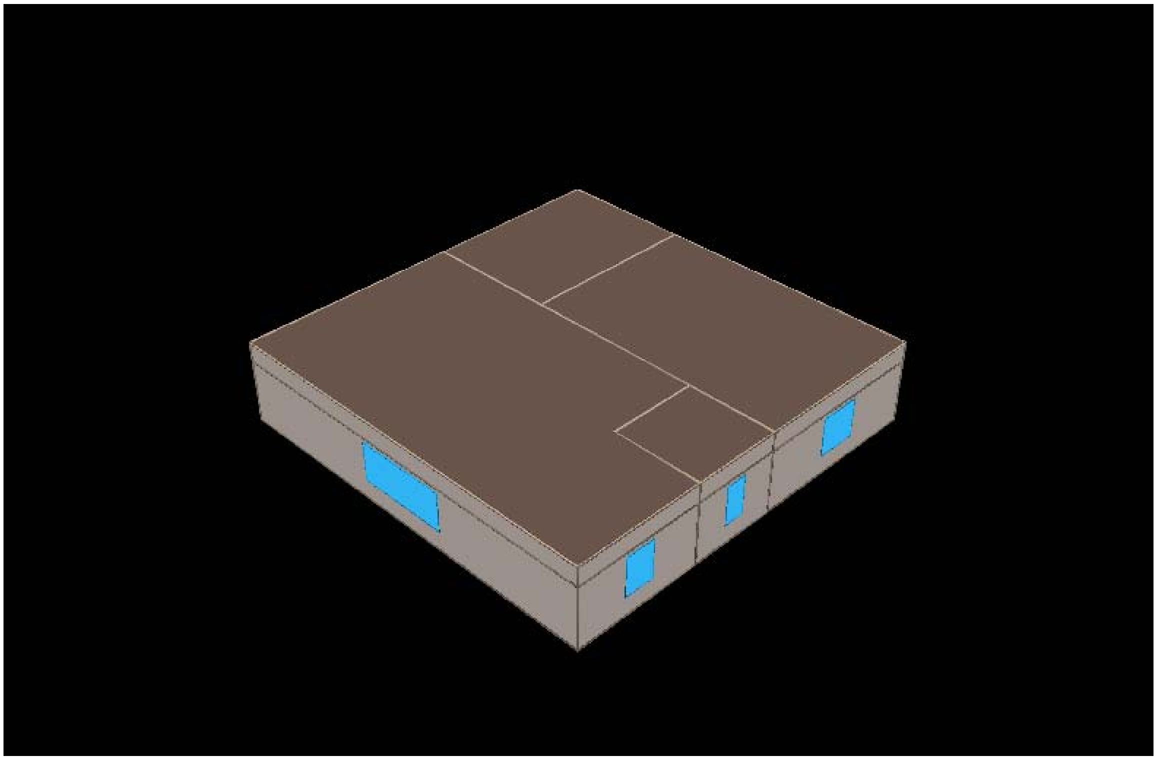
Full-Service Restaurant

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 setpoints	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

A computer-generated sketch of the full-service restaurant prototype is shown below.


Full Service Restaurant Prototype Rendering

Grocery

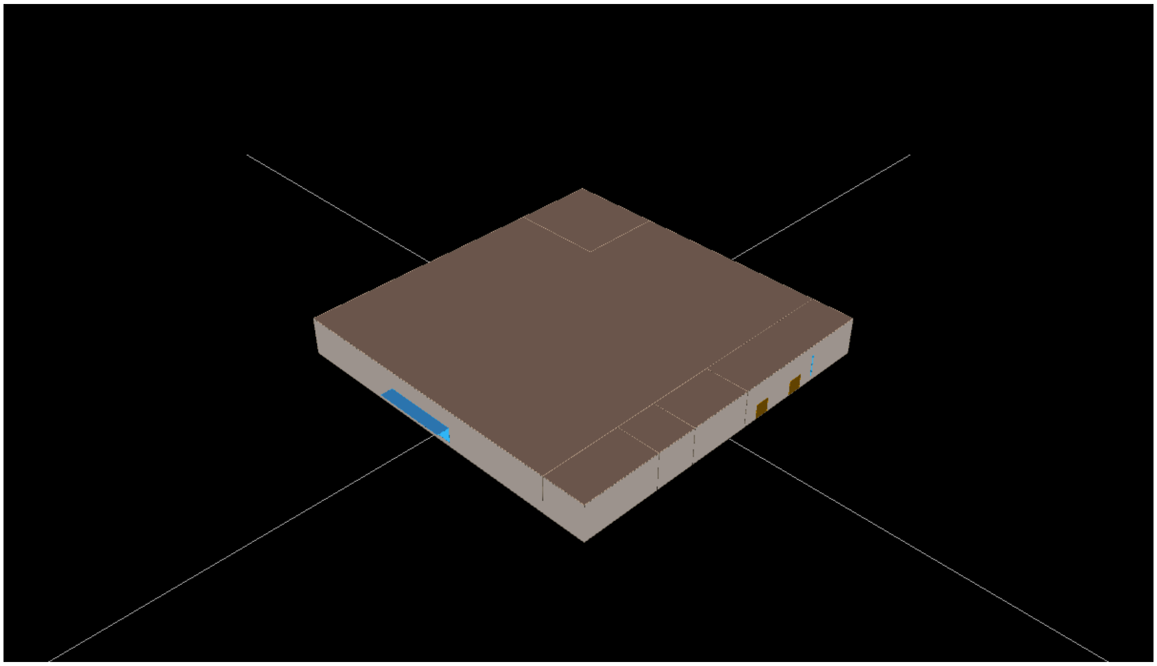
A prototypical building energy simulation model for a grocery building was developed using the DOE-2.2R[36] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 setpoints	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

[36] 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 prototype is shown below.



Grocery Building Rendering

High School

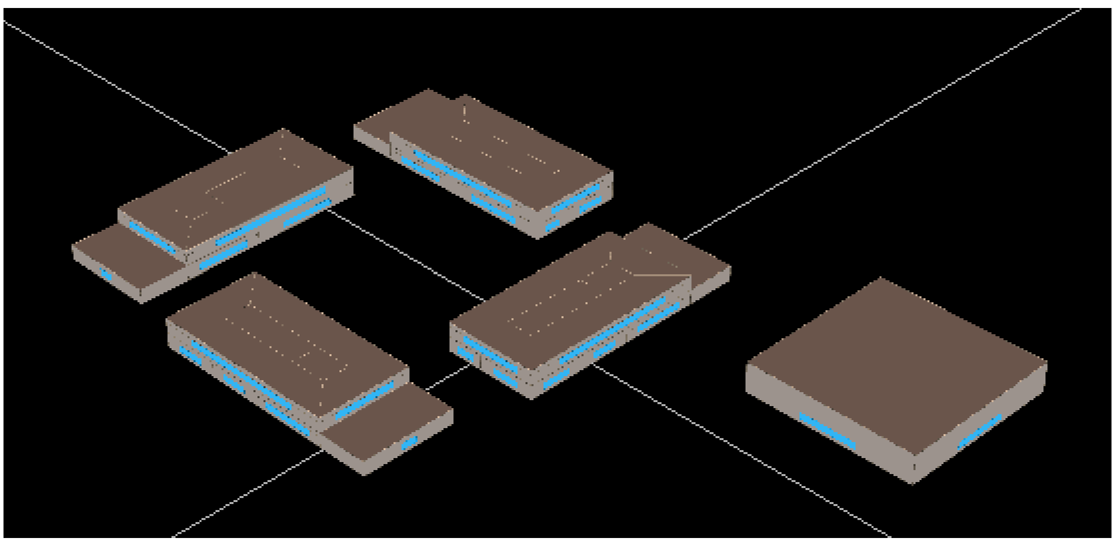
A prototypical building energy simulation model for a high school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of four identical buildings oriented in four different directions, with a common 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

Characteristic	Value
	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 setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown below.



High School Building Rendering

Hospital

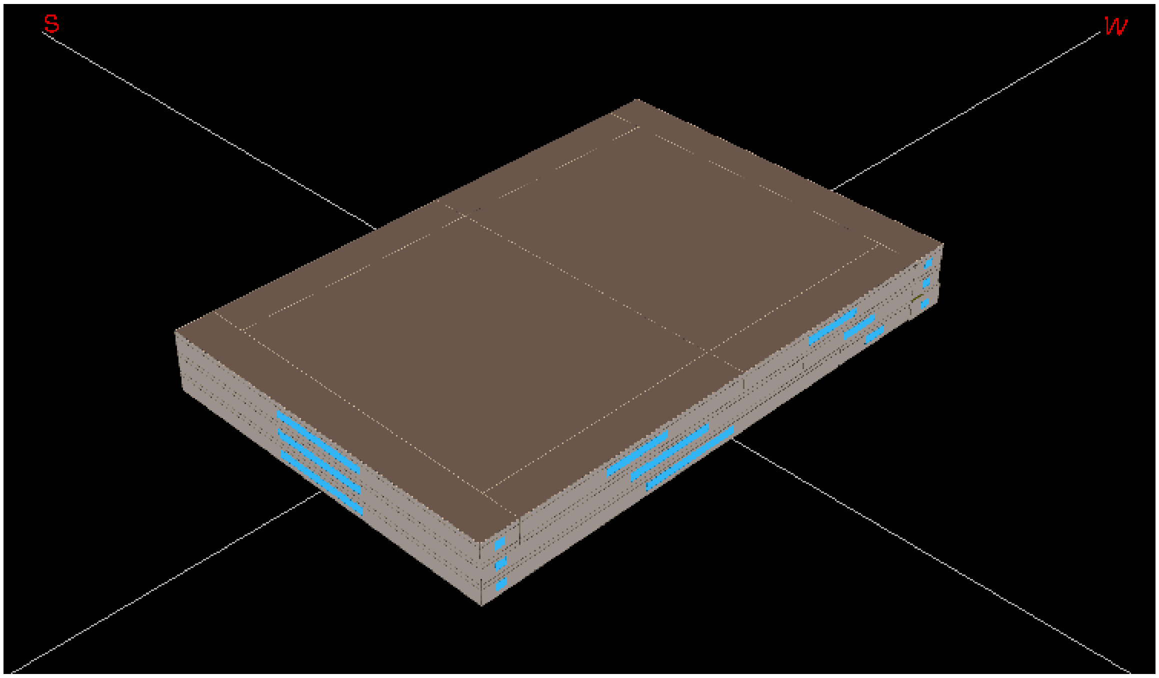
A prototypical building energy simulation model for a large hospital building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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	Multipane; 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 deg F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 deg F setpoint
Thermostat setpoints	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 prototype is shown below.



Hospital Building Rendering

Hotel

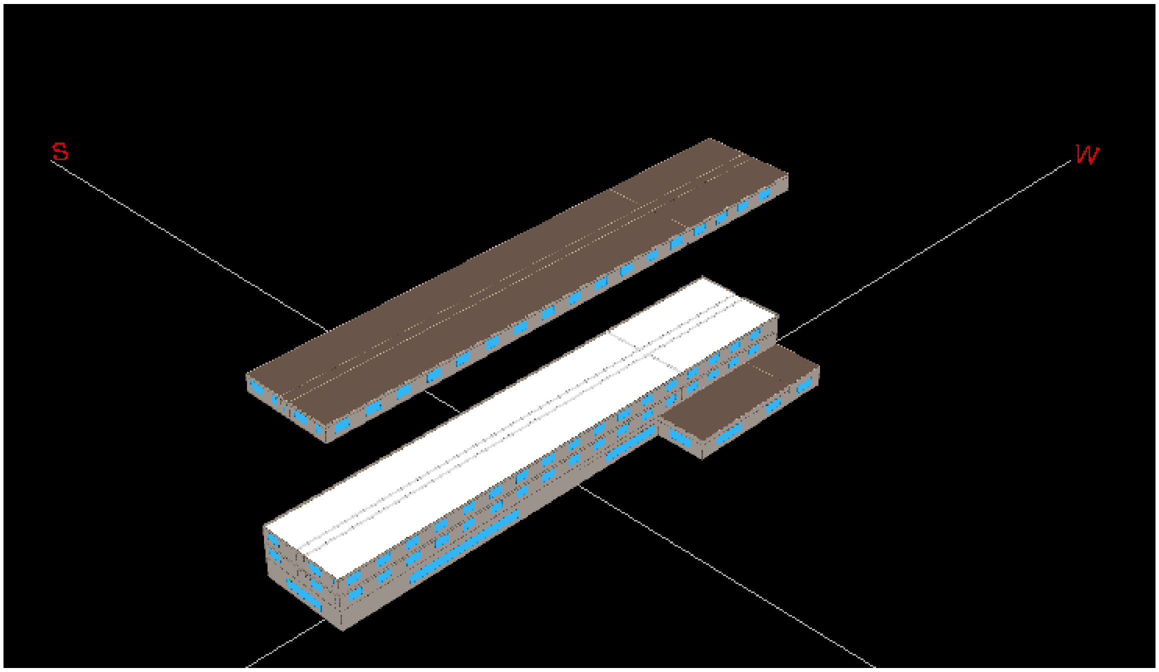
A prototypical building energy simulation model for a hotel building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

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	Multipane; 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

Characteristic	Value
	Lobby – 3.1 W/SF Office – 2.2 W/SF
Plug load density	Bar, cocktail lounge – 1.2 W/SF Corridor – 0.2 W/SF Dining Area – 0.6 W/SF Guest rooms – 0.6 W/SF Kitchen – 3.0 W/SF Laundry – 3.5 W/SF Lobby – 0.6 W/SF Office – 1.7 W/SF
Operating hours	Rooms: 60% occupied 40% unoccupied All others: 24 hr / day
HVAC system type	Central built-up system: All except corridors and rooms 1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer PTAC : Guest rooms PSZ: Corridors
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 deg F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 deg F setpoint
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown below.



Hotel Building Rendering

Large Office

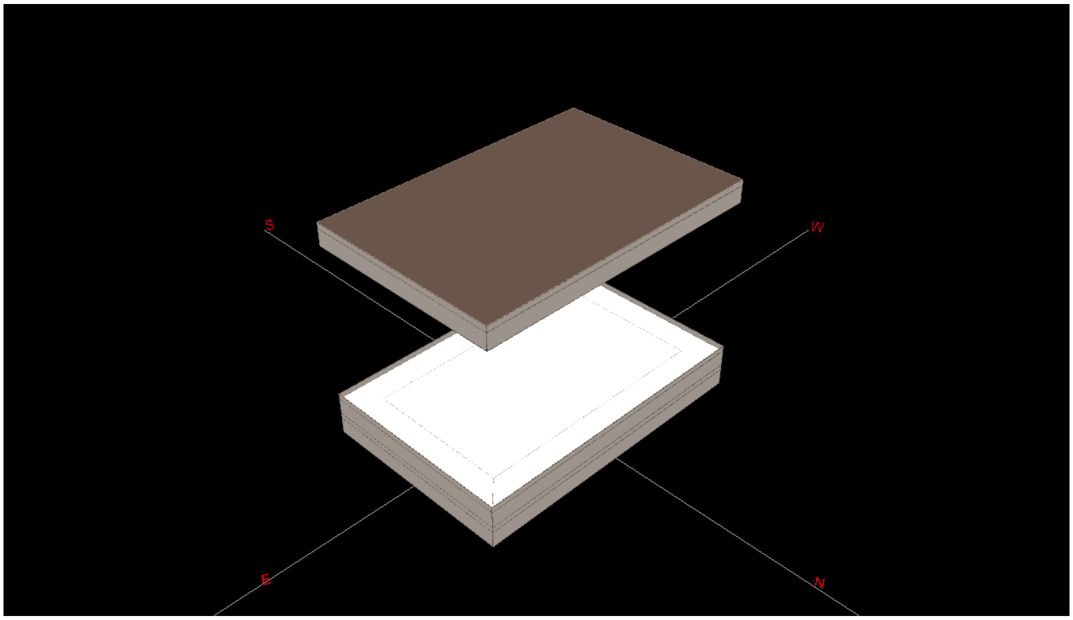
A prototypical building energy simulation model for a large office building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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	Multipane; 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 deg F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 deg F setpoint
Thermostat setpoints	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 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 8 middle floors.



Large Office Building Rendering

Large Retail

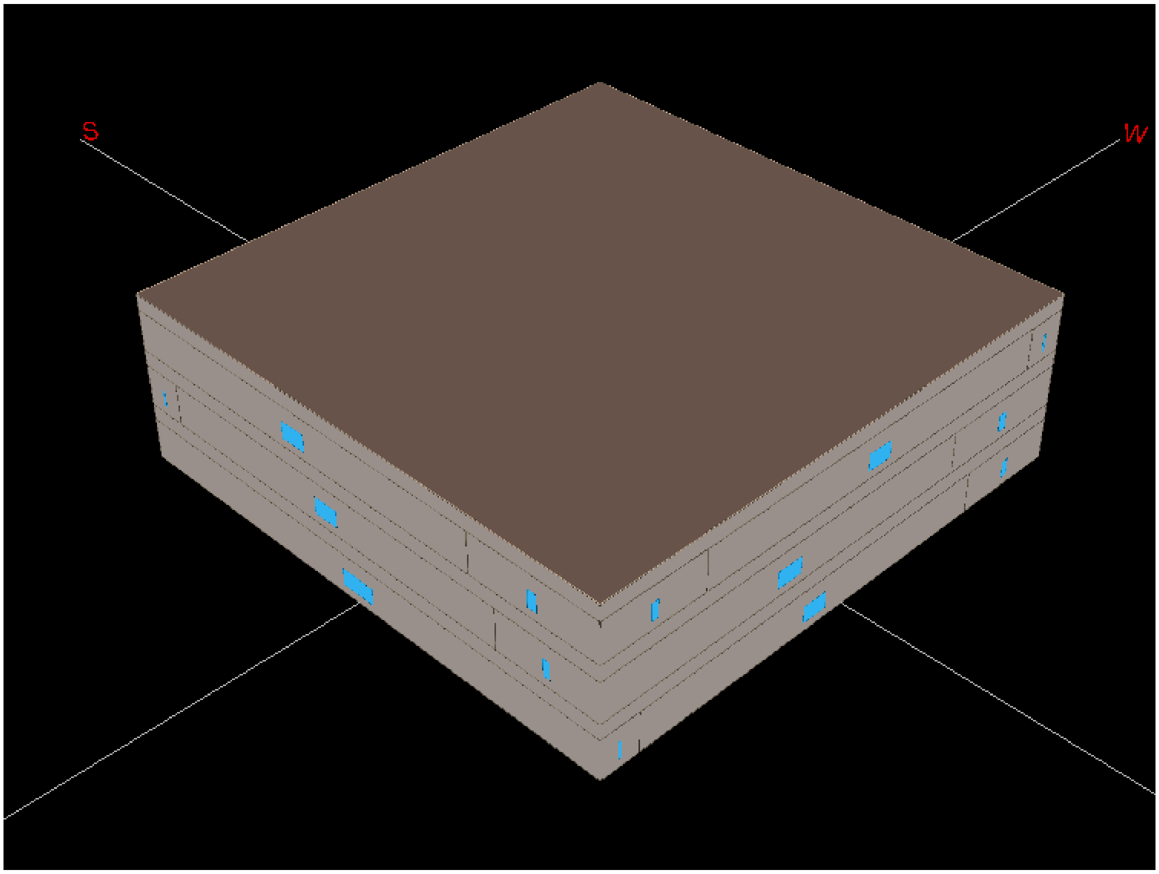
A prototypical building energy simulation model for a large retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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	Multipane; 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 deg F setpoint
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 deg F setpoint
Thermostat setpoints	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 prototype is shown below.



Large Retail Building Rendering

Light Industrial

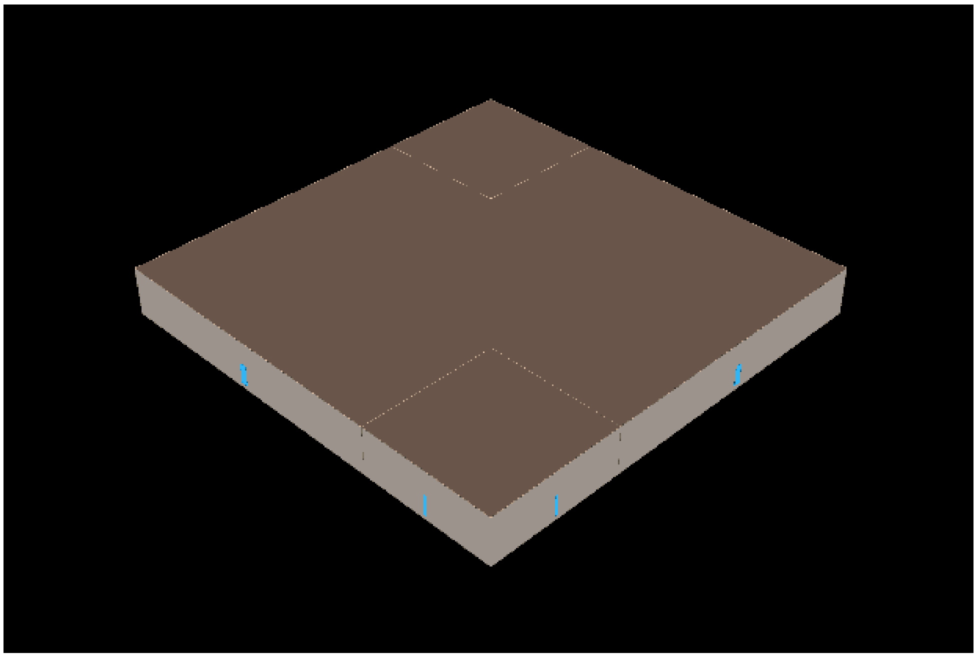
A prototypical building energy simulation model for a light industrial building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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

Characteristic	Value
	Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	500 - 560 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 78 cooling, 70 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown below.



Light Industrial Building Rendering

Motel

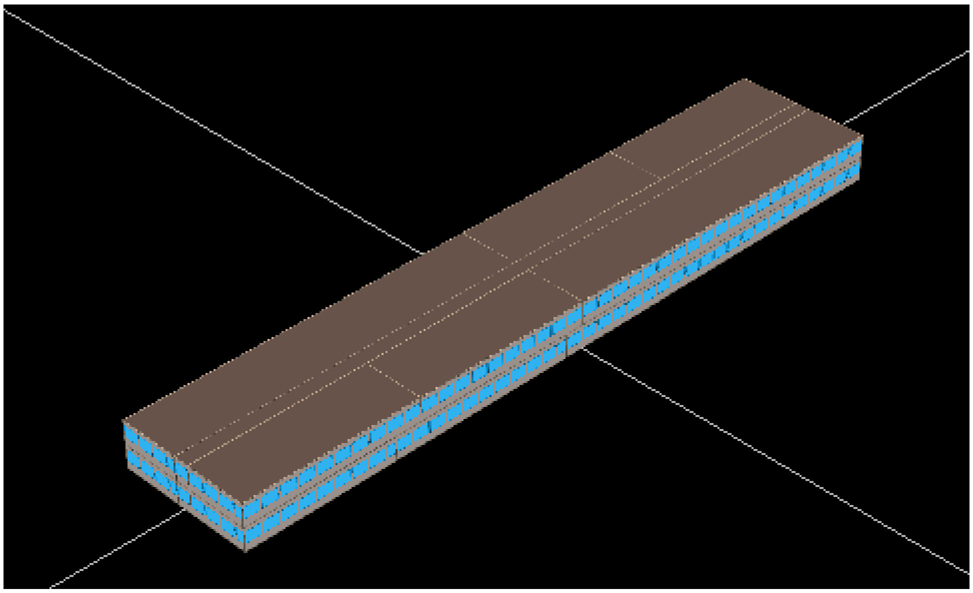
A prototypical building energy simulation model for a motel was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 setpoints	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown below.



Motel Building Rendering

Refrigerated Warehouse

A prototypical building energy simulation model for a refrigerated warehouse building was developed using the DOE-2.2R[37] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

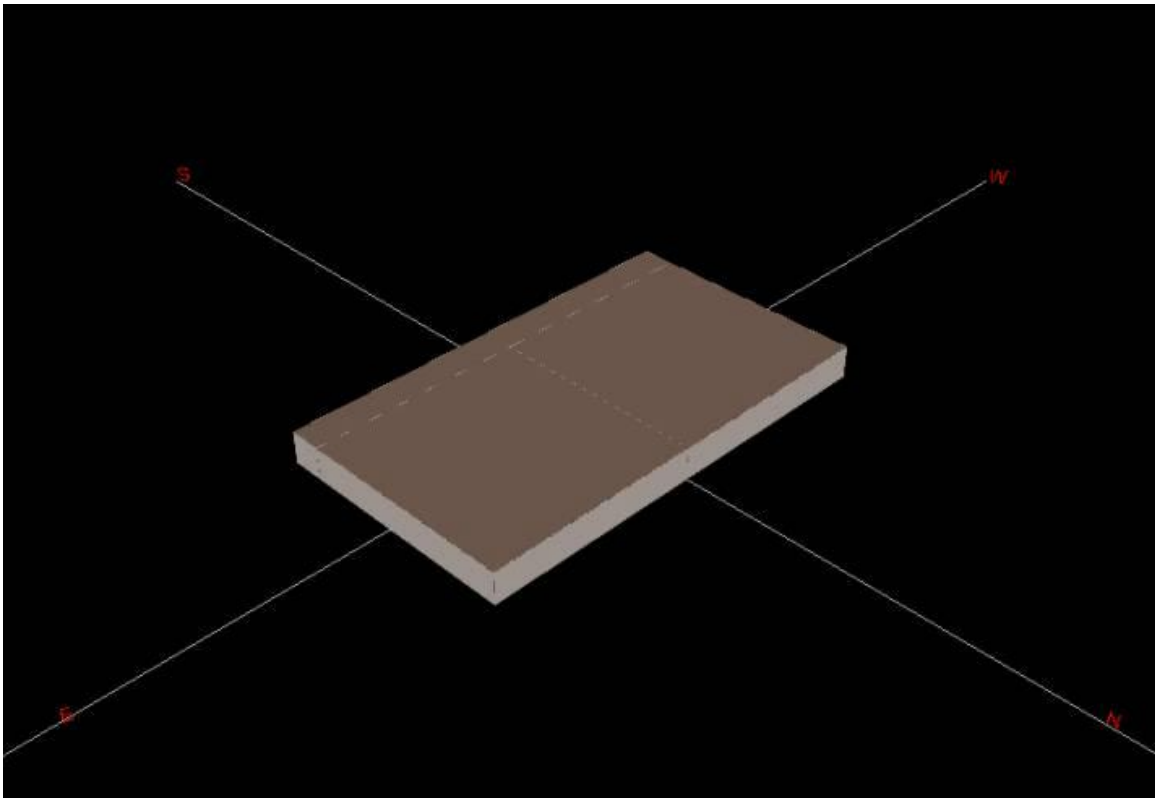
Prototypical Refrigerated Warehouse Model Description

Model Parameter	Value
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

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

Model Parameter	Value
Infiltration rate	Cooler and Freezer: 0.1 ACH Loading Dock: 0.3 ACH
Roof construction	Insulated low mass roof
Roof R-values	Cooler and loading dock – R-23 Freezer – R-46
Roof absorptivity	0.80
Lighting power density	0.6 W/SF
Equipment power density	0.7 W/SF (covers fork lifts and miscellaneous plug loads and equipment)
Operating schedule	24 / 7
No. People	184 max
Evaporator type	Constant volume, continuous fan operation
Evaporator Size (climate zone 13)	Cooler: 102 ton (392 SF/ton) Freezer: 136 ton (295 SF/ton) Dock: 55 ton (218 SF/ton)
Evaporator CFM (climate zone 13)	Cooler: 172,000 cfm (4.3 cfm/SF) Freezer: 131,400 cfm (4.79 cfm/SF) Dock: 55,300 cfm (7.9 cfm/SF)
Compressor type	Ammonia screw compressor with slide valve capacity control (Frick RWF –100 typical)
Compressor configuration	Parallel equal, 3 compressors per suction group, size ratio 0.5, 0.5, 0.5
Suction groups	Low temperature (freezer): -20°F High temperature (cooler and dock): 30°F
Room temperature	Cooler: 40°F Freezer: -10°F Dock: 40°F
Evaporator fan power	0.15 W/CFM (0.32 hp per ton)
Condenser type	Evaporative condenser
Minimum condensing temperature	85
Condenser fan and pump power	330 Btu/watt
Condenser design approach temperature	23°F

A computer-generated sketch of the prototype is shown below.



Refrigerated Warehouse Building Rendering

Religious

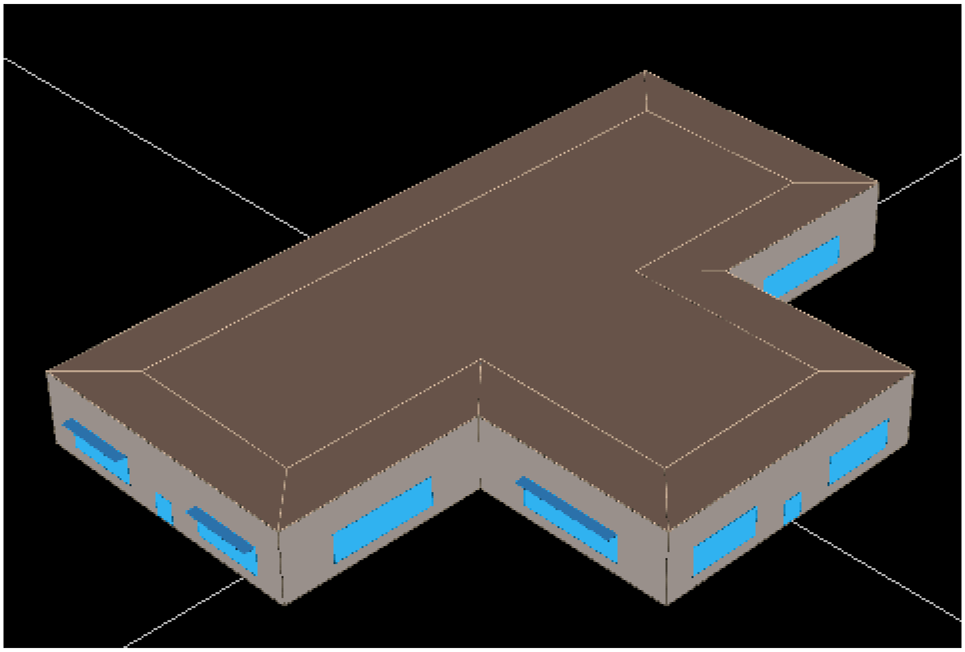
A prototypical building energy simulation model for a religious worship building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 setpoints	Occupied hours: 76 cooling, 70 heating Unoccupied hours: 82 cooling, 64 heating

A computer-generated sketch of the prototype is shown below.



Religious Worship Building Rendering

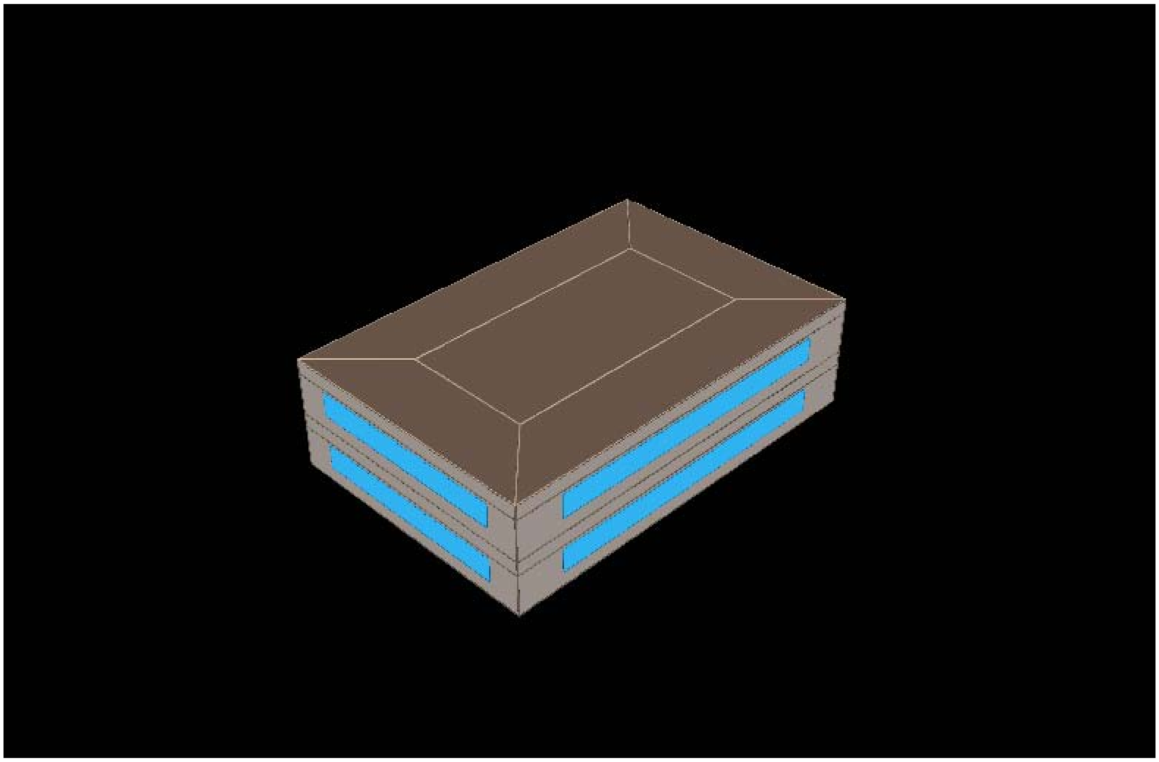
Small Office

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 setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

A computer-generated sketch of the small office prototype is shown below.



Small Office Prototype Building Rendering

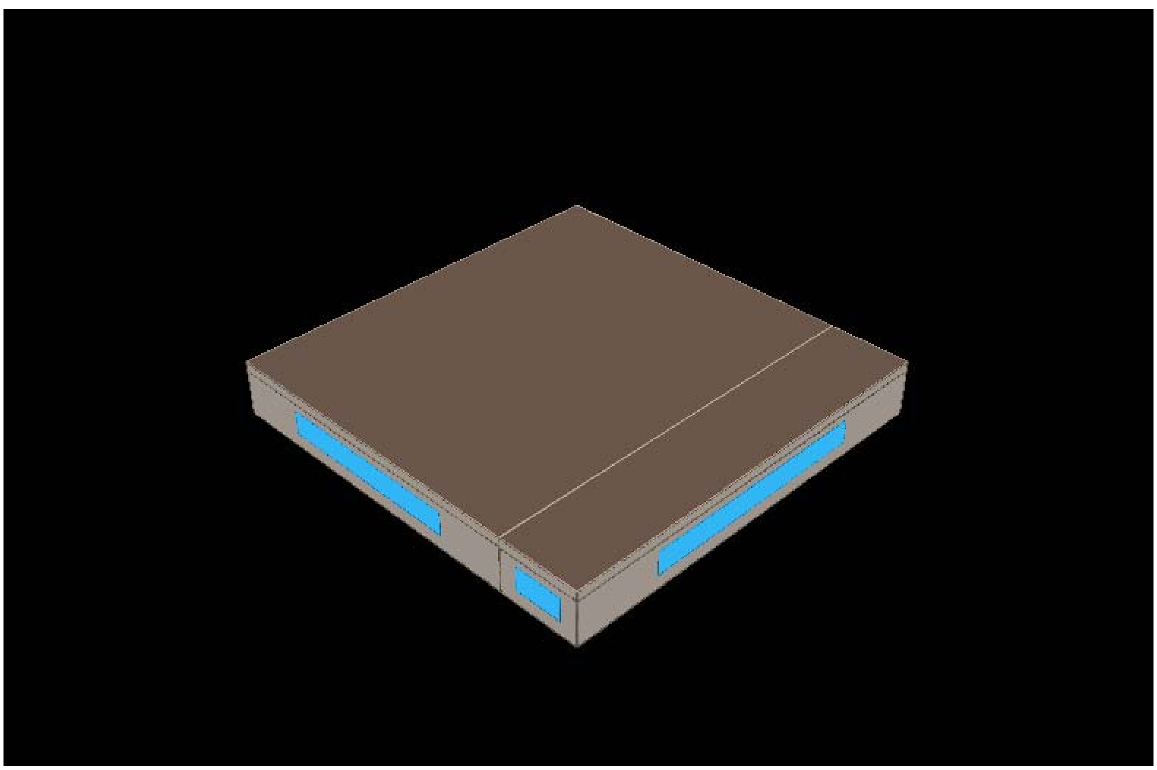
Small Retail

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 setpoints	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.



Small Retail Prototype Building Rendering

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.

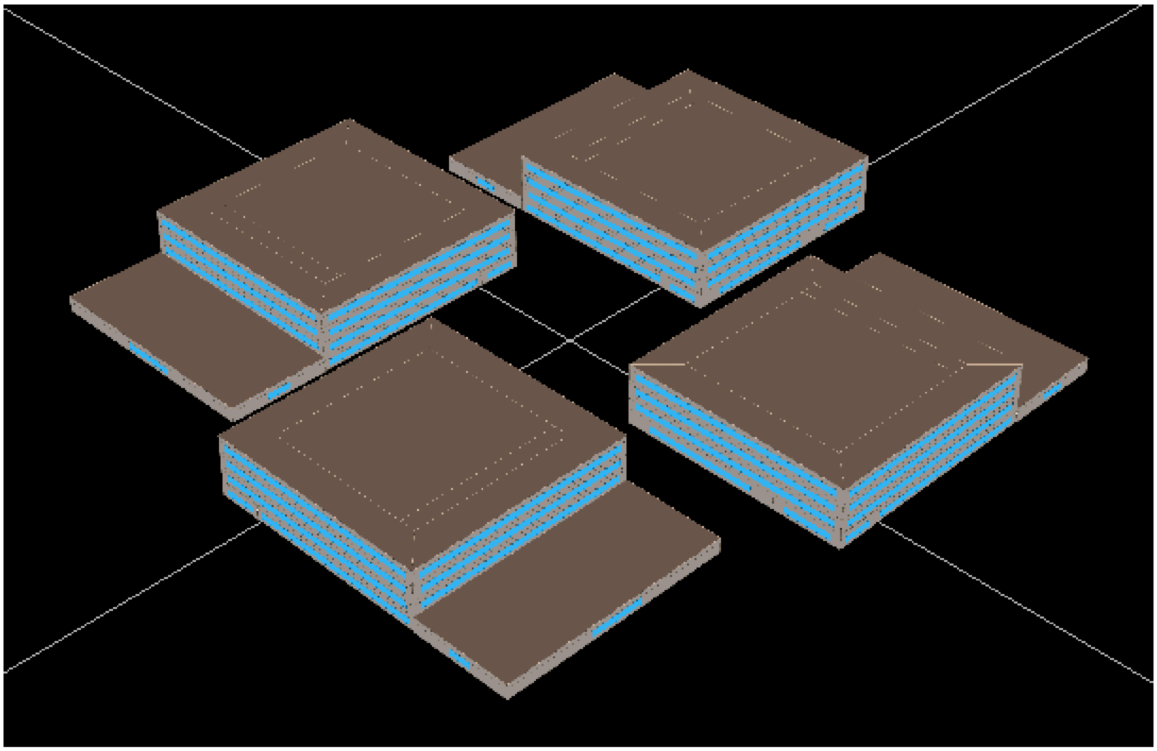
University Prototype Building Description

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
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 setpoints	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 deg F setpoint
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 deg F setpoint

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 prototype is shown below.



University Rendering

Warehouse

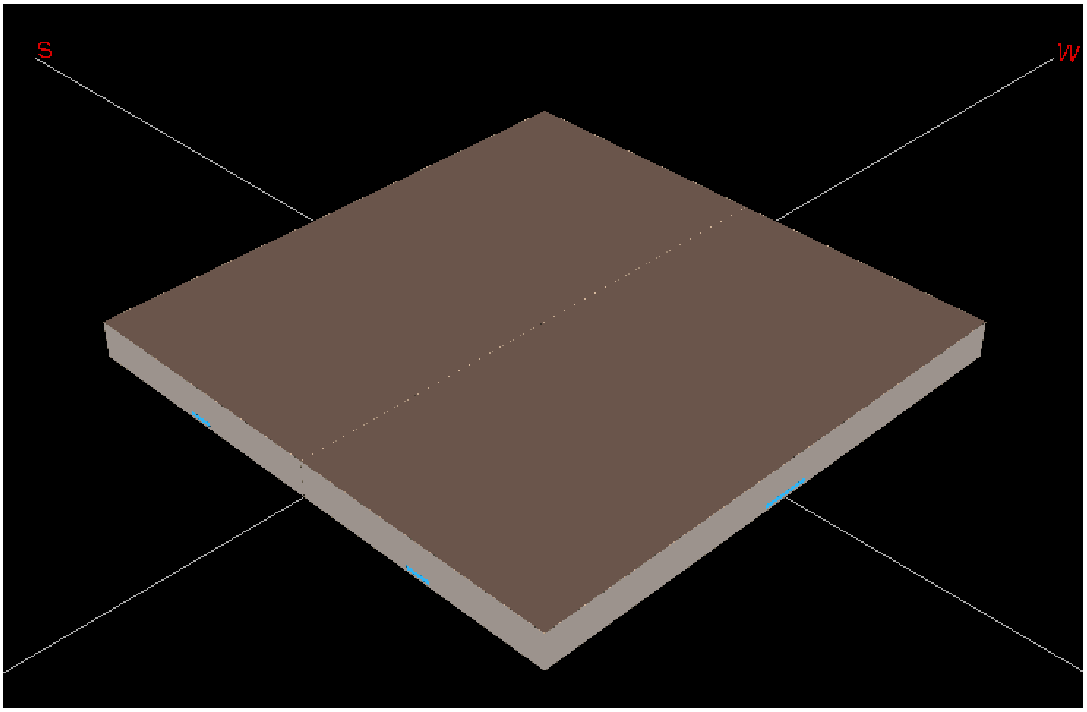
A prototypical building energy simulation model for a warehouse building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

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	Multipane; 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

Characteristic	Value
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Thermostat setpoints	Occupied hours: 80 cooling, 68 heating Unoccupied hours: 85 cooling, 63 heating

A computer-generated sketch of the prototype is shown below.



Warehouse Building Rendering

APPENDIX B. 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.

Weighting Factors for 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

System Type	Old	Average
Room AC	0.629	0.371

Weighting Factors for Multi-family Residential Building Calculations

The fractions of total multi-family lowrise 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. Lowrise buildings were identified as buildings with 2-4 units; or 1 or 2 story buildings with 5 or more units.

Vintage Weights for Lowrise 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 lowrise 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.

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. Savings estimates for large commercial offices and hospitals are developed for several HVAC system and chiller type combinations. The CBECS data were analyzed to develop system type weights for these two building types. The weighting factors for each of the three HVAC system types (constant volume reheat without economizer (CV noecon), constant volume reheat with economizer (CV econ) and variable air volume with economizer (VAV econ) are shown below.

System Type Weights for Built-Up HVAC Systems from CBECS

	Building					
System Type	**Hospital**	**Office**	**Education**	**Lodging**	**Retail**	**Other**
VAV econ	0.836	0.864	0.694		0.836	0.646
CV econ	0.150	0.071	0.153	1.00	0.150	0.305
CV noecon	0.013	0.065	0.153		0.013	0.049

Weighting factors for air cooled vs. water cooled chillers were not available in the CBECS data. For the purpose of the Tech Manual calculations, when the chiller type is not know, equal weights for air cooled and water cooled chillers should be used.

APPENDIX C. STANDARD FIXTURE WATTS

(Reference: NYSERDA Existing Buildings Lighting Table with Circline Additions from CA SPC Table)

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
		Compact Fluorescent Fixtures* Hard-Wired or Pin-Based Only				
CF10/2D	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	Mag-STD	1	10	16
CF10/2D-L	CFD10W	Compact Fluorescent, 2D, (1) 10W lamp	Electronic	1	10	12
CF11/1	CF11W	Compact Fluorescent, (1) 11W lamp	Mag-STD	1	11	13
CF11/2	CF11W	Compact Fluorescent, (2) 11W lamp	Mag-STD	2	11	26
CF16/2D	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	Mag-STD	1	16	26
CF16/2D-L	CFD16W	Compact Fluorescent, 2D, (1) 16W lamp	Electronic	1	16	18
CF18/3-L	CF18W	Compact Fluorescent, (3) 18W lamp	Electronic	3	18	60
CF21/2D	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	Mag-STD	1	21	26
CF21/2D-L	CFD21W	Compact Fluorescent, 2D, (1) 21W lamp	Electronic	1	21	22
CF23/1	CF23W	Compact Fluorescent, (1) 23W lamp	Mag-STD	1	23	29
CF23/1-L	CF23W	Compact Fluorescent, (1) 23W lamp	Electronic	1	23	25
CF26/3-L	CF26W	Compact Fluorescent, (3) 26W lamp	Electronic	3	26	82
CF26/4-L	CF26W	Compact Fluorescent, (4) 26W lamp	Electronic	4	26	108
CF26/6-L	CF26W	Compact Fluorescent, (6) 26W lamp	Electronic	6	26	162
CF26/8-L	CF26W	Compact Fluorescent, (8) 26W lamp	Electronic	8	26	216
CF28/2D	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	Mag-STD	1	28	35
CF28/2D-L	CFD28W	Compact Fluorescent, 2D, (1) 28W lamp	Electronic	1	28	28
CF32/3-L	CF32W	Compact Fluorescent, (3) 32W lamp	Electronic	3	32	114
CF32/4-L	CF32W	Compact Fluorescent, (4) 32W lamp	Electronic	4	32	152
CF32/6-L	CF32W	Compact Fluorescent, (6) 32W lamp	Electronic	6	32	228
CF32/8-L	CF32W	Compact Fluorescent, (8) 32W lamp	Electronic	8	32	304

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
CF38/2D	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Mag-STD	1	38	46
CF38/2D-L	CFD38W	Compact Fluorescent, 2D, (1) 38W lamp	Electronic	1	38	36
CF42/1-L	CF42W	Compact Fluorescent, (1) 42W lamp	Electronic	1	42	48
CF42/2-L	CF42W	Compact Fluorescent, (2) 42W lamp	Electronic	2	42	100
CF42/3-L	CF42W	Compact Fluorescent, (3) 42W lamp	Electronic	3	42	141
CF42/4-L	CF42W	Compact Fluorescent, (4) 42W lamp	Electronic	4	42	188
CF42/6-L	CF42W	Compact Fluorescent, (6) 42W lamp	Electronic	6	42	282
CF42/8-L	CF42W	Compact Fluorescent, (8) 42W lamp	Electronic	8	42	376
CFQ10/1	CFQ10W	Compact Fluorescent, quad, (1) 10W lamp	Mag-STD	1	10	15
CFQ13/1	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp	Mag-STD	1	13	17
CFQ13/1-L	CFQ13W	Compact Fluorescent, quad, (1) 13W lamp, BF=1.05	Electronic	1	13	15
CFQ13/2	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp	Mag-STD	2	13	31
CFQ13/2-L	CFQ13W	Compact Fluorescent, quad, (2) 13W lamp, BF=1.0	Electronic	2	13	28
CFQ13/3	CFQ13W	Compact Fluorescent, quad, (3) 13W lamp	Mag-STD	3	13	48
CFQ15/1	CFQ15W	Compact Fluorescent, quad, (1) 15W lamp	Mag-STD	1	15	20
CFQ17/1	CFQ17W	Compact Fluorescent, quad, (1) 17W lamp	Mag-STD	1	17	24
CFQ17/2	CFQ17W	Compact Fluorescent, quad, (2) 17W lamp	Mag-STD	2	17	48
CFQ18/1	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp	Mag-STD	1	18	26
CFQ18/1-L	CFQ18W	Compact Fluorescent, quad, (1) 18W lamp, BF=1.0	Electronic	1	18	20
CFQ18/2	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp	Mag-STD	2	18	45
CFQ18/2-L	CFQ18W	Compact Fluorescent, quad, (2) 18W lamp, BF=1.0	Electronic	2	18	38
CFQ18/4	CFQ18W	Compact Fluorescent, quad, (4) 18W lamp	Mag-STD	2	18	90
CFQ20/1	CFQ20W	Compact Fluorescent, quad, (1) 20W lamp	Mag-STD	1	20	23
CFQ20/2	CFQ20W	Compact Fluorescent, quad, (2) 20W lamp	Mag-STD	2	20	46
CFQ22/1	CFQ22W	Compact Fluorescent, quad, (1) 22W lamp	Mag-STD	1	22	24

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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/ fix	WATT/ LAMP	WATT/ FIXT
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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/ fix	WATT/ LAMP	WATT/ FIXT
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
F21ILL/T4-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	17	14
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F21LL-R	F17T8	Fluorescent, (1) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	1	17	15
F21LS	F17T8	Fluorescent, (1) 24", T8 lamp, Standard Ballast	Mag-STD	1	17	24
F21GL	F24T5	Fluorescent, (1) 24", STD T5 lamp	Electronic	1	14	18
F21SE	F20T12	Fluorescent, (1) 24", STD lamp	Mag-ES	1	20	26
F21SS	F20T12	Fluorescent, (1) 24", STD lamp	Mag-STD	1	20	28
F21GHL	F24T5/HO	Fluorescent, (1) 24", STD HO T5 lamp	Electronic	1	24	29
F22SHS	F24T12/HO	Fluorescent, (2) 24", HO lamp	Mag-STD	2	35	90
F22GHL	F24T5/HO	Fluorescent, (2) 24", STD HO T5 lamp	Electronic	2	24	55
F22ILE	F17T8	Fluorescent, (2) 24", T-8 Instant Start lamp, Energy Saving Magnetic Ballast	Mag-ES	2	17	45
F22ILL	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	17	33
F22ILL/T4	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	17	31
F22ILL/T4-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	2	17	28
F22ILL-R	F17T8	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	17	29
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F23SE	F20T12	Fluorescent, (3) 24", STD lamp	Mag-ES	3	20	77
F23SS	F20T12	Fluorescent, (3) 24", STD lamp	Mag-STD	3	20	84
F24ILL	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	61
F24ILL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	17	55
F24LL	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	17	68
F24LL-R	F17T8	Fluorescent, (4) 24", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	17	57
F24SE	F20T12	Fluorescent, (4) 24", STD lamp	Mag-ES	4	20	102
F24SS	F20T12	Fluorescent, (4) 24", STD lamp	Mag-STD	4	20	112
F26SE	F20T12	Fluorescent, (6) 24", STD lamp	Mag-ES	6	20	153
F26SS	F20T12	Fluorescent, (6) 24", STD lamp	Mag-STD	6	20	168
F31EE	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-ES	1	25	38
F31EE/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-ES	1	25	33
F31EL	F30T12/ES	Fluorescent, (1) 36", ES lamp	Electronic	1	25	26
F31ES	F30T12/ES	Fluorescent, (1) 36", ES lamp	Mag-STD	1	25	42
F31ES/T2	F30T12/ES	Fluorescent, (1) 36", ES lamp, Tandem wired	Mag-STD	1	25	37
F31ILL	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	25	26
F31ILL/T2	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31ILL/T2-H	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, HLO (BF: .96-1.1), Tandem 2 Lamp Ballast	Electronic	1	25	24
F31ILL/T2-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	25	23
F31ILL/T3	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	25	22
F31ILL/T3-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 3 Lamp Ballast	Electronic	1	25	22
F31ILL/T4	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	25	22
F31ILL/T4-R	F25T8	Fluorescent, (1) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast	Electronic	1	25	22

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
F31SE/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-ES	1	30	37
F31GHL	F36T5/HO	Fluorescent, (1) 36", STD HO T5 lamp	Electronic	1	39	43
F31SHS	F36T12/HO	Fluorescent, (1) 36", HO lamp	Mag-STD	1	50	70
F31SL	F30T12	Fluorescent, (1) 36", STD lamp	Electronic	1	30	31
F31GL	F36T5	Fluorescent, (1) 36", STD T5 lamp	Electronic	1	21	27
F31SS	F30T12	Fluorescent, (1) 36", STD lamp	Mag-STD	1	30	46
F31SS/T2	F30T12	Fluorescent, (1) 36", STD lamp, Tandem wired	Mag-STD	1	30	41
F32EE	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-ES	2	25	66
F32EL	F30T12/ES	Fluorescent, (2) 36", ES lamp	Electronic	2	25	50
F32ES	F30T12/ES	Fluorescent, (2) 36", ES lamp	Mag-STD	2	25	73
F32ILL	F25T8	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	46
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
F32LE	F25T8	Fluorescent, (2) 36", T-8 lamp	Mag-ES	2	25	65

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F32LL	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	2	25	46
F32LL/T4	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	25	45
F32LL-H	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1)	Electronic	2	25	50
F32LL-R	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	2	25	42
F32LL-V	F25T8	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, VHLO (BF>1.1)	Electronic	2	25	70
F32SE	F30T12	Fluorescent, (2) 36", STD lamp	Mag-ES	2	30	74
F32GHL	F36T5/HO	Fluorescent, (1) 36", STD HO T5 lamp	Electronic	2	39	85
F32SHS	F36T12/HO	Fluorescent, (2) 36", HO, lamp	Mag-STD	2	50	114
F32SL	F30T12	Fluorescent, (2) 36", STD lamp	Electronic	2	30	58
F32GL	F36T5	Fluorescent, (1) 36", STD T5 lamp	Electronic	2	21	52
F32SS	F30T12	Fluorescent, (2) 36", STD lamp	Mag-STD	2	30	81
F33ES	F30T12/ES	Fluorescent, (3) 36", ES lamp	Mag-STD	3	25	115
F33ILL	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	67
F33ILL-R	F25T8	Fluorescent, (3) 36", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	66
F33LL	F25T8	Fluorescent, (3) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	3	25	72
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F34SS	F30T12	Fluorescent, (4) 36", STD lamp	Mag-STD	4	30	162
F36EE	F30T12/ES	Fluorescent, (6) 36", ES lamp	Mag-ES	6	25	198
F36ILL-R	F25T8	Fluorescent, (6) 36", T-8 lamp, Instant Start Ballast, RLO (BF<.85)	Electronic	6	25	134
F36SE	F30T12	Fluorescent, (6) 36", STD lamp	Mag-ES	6	30	238
F40EE/D1	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (1) hot ballast	Mag-ES	0	0	4
F40EE/D2	None	Fluorescent, (0) 48" lamp, Completely delamped fixture with (2) hot ballast	Mag-ES	0	0	8
F41EE	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-ES	1	34	43
F41EE/D2	F40T12/ES	Fluorescent, (1) 48", ES lamp, 2 ballast	Mag-ES	1	34	43
F41EE/T2	F40T12/ES	Fluorescent, (1) 48", ES lamp, tandem wired, 2-lamp ballast	Mag-ES	1	34	36
F41EHS	F48T12/HO/ ES	Fluorescent, (1) 48", ES HO lamp	Mag-STD	1	55	80
F41EIS	F48T12/ES	Fluorescent, (1) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	1	30	51
F41EL	F40T12/ES	Fluorescent, (1) 48", T12 ES lamp, Electronic Ballast	Electronic	1	34	32
F41EL/T2	F40T12/ES	Fluorescent, (1) 48", T-12 ES lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	34	32
F41ES	F40T12/ES	Fluorescent, (1) 48", ES lamp	Mag-STD	1	34	50
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F41SILL-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	30	25
F41SILL/T2-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	30	24
F41SILL/T3-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	30	24
F41SILL/T4-R	F30T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	30	23
F41SILL-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	30	37
F41SILL/T2-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	30	36
F41SILL/T3-H	F30T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	30	36
F41SSILL	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	1	28	26
F41SSILL/T2	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	28	25
F41SSILL/T3	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 3 Lamp Ballast	Electronic	1	28	25
F41SSILL/T4	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	1	28	24
F41SSILL-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	1	28	23
F41SSILL/T2-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	28	22
F41SSILL/T3-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 3 Lamp Ballast	Electronic	1	28	22
F41SSILL/T4-R	F28T8	Fluorescent, (1) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	1	28	21
F41SSILL-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	1	28	33
F41SSILL/T2-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	28	32
F41SSILL/T3-H	F28T8	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1), Tandem 3 Lamp Ballast	Electronic	1	28	32
F41ILL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	30
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
F41LE	F32T8	Fluorescent, (1) 48", T-8 lamp	Mag-ES	1	32	35
F41LL	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	1	32	32
F41LL/T2	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	32	30
F41LL/T2-H	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, HLO (BF:.96-1.1), Tandem 2 Lamp Ballast	Electronic	1	32	39
F41LL/T2-R	F32T8	Fluorescent, (1) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85), Tandem 2 Lamp Ballast	Electronic	1	32	27
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F41SIL/T2	F48T12	Fluorescent, (1) 48", STD IS lamp, Electronic ballast, tandem wired	Electronic	1	39	37
F41SIS	F48T12	Fluorescent, (1) 48", STD IS lamp	Mag-STD	1	39	60
F41SIS/T2	F48T12	Fluorescent, (1) 48", STD IS lamp, tandem to 2-lamp ballast	Mag-STD	1	39	52
F41GL	F48T5	Fluorescent, (1) 48", STD T5 lamp	Electronic	1	28	32
F41SL/T2	F40T12	Fluorescent, (1) 48", T-12 STD lamp, Rapid Start Ballast, NLO (BF: .85-.95), Tandem 2 Lamp Ballast	Electronic	1	40	36
F41SS	F40T12	Fluorescent, (1) 48", STD lamp	Mag-STD	1	40	57
F41SVS	F48T12/VHO	Fluorescent, (1) 48", STD VHO lamp	Mag-STD	1	110	135
F41TS	F40T10	Fluorescent, (1) 48", T-10 lamp	Mag-STD	1	40	51
F42EE	F40T12/ES	Fluorescent, (2) 48", ES lamp	Mag-ES	2	34	72
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F42SSILL	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	2	28	48
F41SSILL/T4	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), Tandem 4 Lamp Ballast	Electronic	2	28	47
F42SSILL-R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	2	28	45
F41SSILL/T4 -R	F28T8	Fluorescent, (2) 48", Super T-8 lamp, IS Ballast, RLO (BF<0.85), Tandem 4 Lamp Ballast	Electronic	2	28	44
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
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F42SS	F40T12	Fluorescent, (2) 48", STD lamp	Mag-STD	2	40	94
F42SVS	F48T12/VHO	Fluorescent, (2) 48", STD VHO lamp	Mag-STD	2	110	242
F43EE	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-ES	3	34	115
F43EHS	F48T12/HO/ ES	Fluorescent, (3) 48", ES HO lamp (3.5' lamp)	Mag-STD	3	55	215
F43EIS	F48T12/ES	Fluorescent, (3) 48" ES Instant Start lamp. Magnetic ballast	Mag-STD	3	30	133
F43EL	F40T12/ES	Fluorescent, (3) 48", T12 ES lamps, Electronic Ballast	Electronic	3	34	92
F43ES	F40T12/ES	Fluorescent, (3) 48", ES lamp	Mag-STD	3	34	130
F43EVS	F48T12/VHO /ES	Fluorescent, (3) 48", VHO ES lamp	Mag-STD	3		333
F43IAL-R	F25T12	Fluorescent, (3) 48", F25T12 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	25	60
F43ILL	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	32	89
F43SILL	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	30	78
F43SILL-R	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	30	70
F43SILL-H	F30T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-3.3)	Electronic	3	30	105
F43SSILL	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	3	28	72
F43SSILL-R	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	3	28	66
F43SSILL-H	F28T8	Fluorescent, (3) 48", Super T-8 lamp, Instant Start Ballast, HLO (BF:.96-3.3)	Electronic	3	28	98
F43ILL/2	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	3	32	90
F43ILL-H	F32T8	Fluorescent, (3) 48", T-8 lamp, Instant Start Ballast, HLO (BF:.96-1.1)	Electronic	3	32	93
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F43LL-R	F32T8	Fluorescent, (3) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	3	32	76
F43SE	F40T12	Fluorescent, (3) 48", STD lamp	Mag-ES	3	40	136
F43GHL	F48T5/HO	Fluorescent, (3) 48", STD HO T5 lamp	Electronic	3	54	177
F43SHS	F48T12/HO	Fluorescent, (3) 48", STD HO lamp	Mag-STD	3	60	230
F43SIL	F40T12	Fluorescent, (3) 48", STD IS lamp, Electronic ballast	Electronic	3	39	120
F43SIS	F48T12	Fluorescent, (3) 48", STD IS lamp	Mag-STD	3	39	162
F43SS	F40T12	Fluorescent, (3) 48", STD lamp	Mag-STD	3	40	151
F43SVS	F48T12/VHO	Fluorescent, (3) 48", STD VHO lamp	Mag-STD	3	110	377
F44EE	F40T12/ES	Fluorescent, (4) 48", ES lamp	Mag-ES	4	34	144
F44EE/D4	F40T12/ES	Fluorescent, (4) 48", ES lamp, 4 Ballasts (delamped)	Mag-ES	4	34	152
F44EHS	F48T12/HO/ ES	Fluorescent, (4) 48", ES HO lamp	Mag-STD	4	55	270
F44EIS	F48T12/ES	Fluorescent, (4) 48" ES Instant Start lamp, Magnetic ballast	Mag-STD	4	30	164
F44EL	F40T12/ES	Fluorescent, (4) 48", T12 ES lamp, Electronic Ballast	Electronic	4	34	120
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F44ILL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	4	32	102
F44LE	F32T8	Fluorescent, (4) 48", T-8 lamp	Mag-ES	4	32	142
F44LL	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Electronic	4	32	118
F44LL/2	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95), (2) ballast	Electronic	4	32	120
F44LL-R	F32T8	Fluorescent, (4) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Electronic	4	32	105
F44SE	F40T12	Fluorescent, (4) 48", STD lamp	Mag-ES	4	40	172
F44GHL	F48T5/HO	Fluorescent, (4) 48", STD HO T5 lamp	Electronic	4	54	234
F44SHS	F48T12/HO	Fluorescent, (4) 48", STD HO lamp	Mag-STD	4	60	290
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
F48ILL	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Electronic	8	32	224
F48ILL-R	F32T8	Fluorescent, (8) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)	Electronic	8	32	204
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
FU1LL-R	FU31T8/6	Fluorescent, (1) U-Tube, T-8 lamp, RLO (BF<0.85)	Electronic	1	31	27
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
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		1	100	100
I100/2	I100	Incandescent, (2) 100W lamp		2	100	200
I100/3	I100	Incandescent, (3) 100W lamp		3	100	300
I100/4	I100	Incandescent, (4) 100W lamp		4	100	400
I100/5	I100	Incandescent, (5) 100W lamp		5	100	500
I1000/1	I1000	Incandescent, (1) 1000W lamp		1	1000	1000
I100E/1	I100/ES	Incandescent, (1) 100W ES lamp		1	90	90
I100EL/1	I100/ES/LL	Incandescent, (1) 100W ES/LL lamp		1	90	90

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
I120/1	I120	Incandescent, (1) 120W lamp		1	120	120
I120/2	I120	Incandescent, (2) 120W lamp		2	120	240
I125/1	I125	Incandescent, (1) 125W lamp		1	125	125
I135/1	I135	Incandescent, (1) 135W lamp		1	135	135
I135/2	I135	Incandescent, (2) 135W lamp		2	135	270
I15/1	I15	Incandescent, (1) 15W lamp		1	15	15
I15/2	I15	Incandescent, (2) 15W lamp		2	15	30
I150/1	I150	Incandescent, (1) 150W lamp		1	150	150
I150/2	I150	Incandescent, (2) 150W lamp		2	150	300
I1500/1	I1500	Incandescent, (1) 1500W lamp		1	1500	1500
I150E/1	I150/ES	Incandescent, (1) 150W ES lamp		1	135	135
I150EL/1	I150/ES/LL	Incandescent, (1) 150W ES/LL lamp		1	135	135
I170/1	I170	Incandescent, (1) 170W lamp		1	170	170
I20/1	I20	Incandescent, (1) 20W lamp		1	20	20
I20/2	I20	Incandescent, (2) 20W lamp		2	20	40
I200/1	I200	Incandescent, (1) 200W lamp		1	200	200
I200/2	I200	Incandescent, (2) 200W lamp		2	200	400
I2000/1	I2000	Incandescent, (1) 2000W lamp		1	2000	2000
I200L/1	I200/LL	Incandescent, (1) 200W LL lamp		1	200	200
I25/1	I25	Incandescent, (1) 25W lamp		1	25	25
I25/2	I25	Incandescent, (2) 25W lamp		2	25	50
I25/4	I25	Incandescent, (4) 25W lamp		4	25	100
I250/1	I250	Incandescent, (1) 250W lamp		1	250	250
I300/1	I300	Incandescent, (1) 300W lamp		1	300	300
I34/1	I34	Incandescent, (1) 34W lamp		1	34	34

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
I34/2	I34	Incandescent, (2) 34W lamp		2	34	68
I36/1	I36	Incandescent, (1) 36W lamp		1	36	36
I40/1	I40	Incandescent, (1) 40W lamp		1	40	40
I40/2	I40	Incandescent, (2) 40W lamp		2	40	80
I400/1	I400	Incandescent, (1) 400W lamp		1	400	400
I40E/1	I40/ES	Incandescent, (1) 40W ES lamp		1	34	34
I40EL/1	I40/ES/LL	Incandescent, (1) 40W ES/LL lamp		1	34	34
I42/1	I42	Incandescent, (1) 42W lamp		1	42	42
I448/1	I448	Incandescent, (1) 448W lamp		1	448	448
I45/1	I45	Incandescent, (1) 45W lamp		1	45	45
I50/1	I50	Incandescent, (1) 50W lamp		1	50	50
I50/2	I50	Incandescent, (2) 50W lamp		2	50	100
I500/1	I500	Incandescent, (1) 500W lamp		1	500	500
I52/1	I52	Incandescent, (1) 52W lamp		1	52	52
I52/2	I52	Incandescent, (2) 52W lamp		2	52	104
I54/1	I54	Incandescent, (1) 54W lamp		1	54	54
I54/2	I54	Incandescent, (2) 54W lamp		2	54	108
I55/1	I55	Incandescent, (1) 55W lamp		1	55	55
I55/2	I55	Incandescent, (2) 55W lamp		2	55	110
I60/1	I60	Incandescent, (1) 60W lamp		1	60	60
I60/2	I60	Incandescent, (2) 60W lamp		2	60	120
I60/3	I60	Incandescent, (3) 60W lamp		3	60	180
I60/4	I60	Incandescent, (4) 60W lamp		4	60	240
I60/5	I60	Incandescent, (5) 60W lamp		5	60	300
I60E/1	I60/ES	Incandescent, (1) 60W ES lamp		1	52	52

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
I60EL/1	I60/ES/LL	Incandescent, (1) 60W ES/LL lamp		1	52	52
I65/1	I65	Incandescent, (1) 65W lamp		1	65	65
I65/2	I65	Incandescent, (2) 65W lamp		2	65	130
I67/1	I67	Incandescent, (1) 67W lamp		1	67	67
I67/2	I67	Incandescent, (2) 67W lamp		2	67	134
I67/3	I67	Incandescent, (3) 67W lamp		3	67	201
I69/1	I69	Incandescent, (1) 69W lamp		1	69	69
I7.5/1	I7.5	Tungsten exit light, (1) 7.5 W lamp, used in night light application		1	7.5	8
I7.5/2	I7.5	Tungsten exit light, (2) 7.5 W lamp, used in night light application		2	7.5	15
I72/1	I72	Incandescent, (1) 72W lamp		1	72	72
I75/1	I75	Incandescent, (1) 75W lamp		1	75	75
I75/2	I75	Incandescent, (2) 75W lamp		2	75	150
I75/3	I75	Incandescent, (3) 75W lamp		3	75	225
I75/4	I75	Incandescent, (4) 75W lamp		4	75	300
I750/1	I750	Incandescent, (1) 750W lamp		1	750	750
I75E/1	I75/ES	Incandescent, (1) 75W ES lamp		1	67	67
I75EL/1	I75/ES/LL	Incandescent, (1) 75W ES/LL lamp		1	67	67
I80/1	I80	Incandescent, (1) 80W lamp		1	80	80
I85/1	I85	Incandescent, (1) 85W lamp		1	85	85
I90/1	I90	Incandescent, (1) 90W lamp		1	90	90
I90/2	I90	Incandescent, (2) 90W lamp		2	90	180
I90/3	I90	Incandescent, (3) 90W lamp		3	90	270
I93/1	I93	Incandescent, (1) 93W lamp		1	93	93
I95/1	I95	Incandescent, (1) 95W lamp		1	95	95
I95/2	I95	Incandescent, (2) 95W lamp		2	95	190

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
		Halogen Incandescent Fixtures				
H100/1	H100	Halogen Incandescent, (1) 100W lamp		1	100	100
H1000/1	H1000	Halogen Incandescent, (1) 1000W lamp		1	1000	1000
H1200/1	H1200	Halogen Incandescent, (1) 1200W lamp		1	1200	1200
H150/1	H150	Halogen Incandescent, (1) 150W lamp		1	150	150
H150/2	H150	Halogen Incandescent, (2) 150W lamp		2	150	300
H1500/1	H1500	Halogen Incandescent, (1) 1500W lamp		1	1500	1500
H200/1	H200	Halogen Incandescent, (1) 200W lamp		1	200	200
H250/1	H250	Halogen Incandescent, (1) 250W lamp		1	250	250
H300/1	H300	Halogen Incandescent, (1) 300W lamp		1	300	300
H35/1	H35	Halogen Incandescent, (1) 35W lamp		1	35	35
H350/1	H350	Halogen Incandescent, (1) 350W lamp		1	350	350
H40/1	H40	Halogen Incandescent, (1) 40W lamp		1	40	40
H400/1	H400	Halogen Incandescent, (1) 400W lamp		1	400	400
H42/1	H42	Halogen Incandescent, (1) 42W lamp		1	42	42
H425/1	H425	Halogen Incandescent, (1) 425W lamp		1	425	425
H45/1	H45	Halogen Incandescent, (1) 45W lamp		1	45	45
H45/2	H45	Halogen Incandescent, (2) 45W lamp		2	45	90
H50/1	H50	Halogen Incandescent, (1) 50W lamp		1	50	50
H50/2	H50	Halogen Incandescent, (2) 50W lamp		2	50	100
H500/1	H500	Halogen Incandescent, (1) 500W lamp		1	500	500
H52/1	H52	Halogen Incandescent, (1) 52W lamp		1	52	52
H55/1	H55	Halogen Incandescent, (1) 55W lamp		1	55	55
H55/2	H55	Halogen Incandescent, (2) 55W lamp		2	55	110
H60/1	H60	Halogen Incandescent, (1) 60W lamp		1	60	60

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
H72/1	H72	Halogen Incandescent, (1) 72W lamp		1	72	72
H75/1	H75	Halogen Incandescent, (1) 75W lamp		1	75	75
H75/2	H75	Halogen Incandescent, (2) 75W lamp		2	75	150
H750/1	H750	Halogen Incandescent, (1) 750W lamp		1	750	750
H90/1	H90	Halogen Incandescent, (1) 90W lamp		1	90	90
H90/2	H90	Halogen Incandescent, (2) 90W lamp		2	90	180
H900/1	H900	Halogen Incandescent, (1) 900W lamp		1	900	900
HLV20/1	H20/LV	Halogen Low Voltage Incandescent, (1) 20W lamp		1	20	30
HLV25/1	H25/LV	Halogen Low Voltage Incandescent, (1) 25W lamp		1	25	35
HLV35/1	H35/LV	Halogen Low Voltage Incandescent, (1) 35W lamp		1	35	45
HLV42/1	H42/LV	Halogen Low Voltage Incandescent, (1) 42W lamp		1	42	52
HLV50/1	H50/LV	Halogen Low Voltage Incandescent, (1) 50W lamp		1	50	60
HLV65/1	H65/LV	Halogen Low Voltage Incandescent, (1) 65W lamp		1	65	75
HLV75/1	H75/LV	Halogen Low Voltage Incandescent, (1) 75W lamp		1	75	85
		QL Induction Fixtures				
QL55/1	QL55	QL Induction, (1) 55W lamp	Generator	1	55	55
QL85/1	QL85	QL Induction, (1) 85W lamp	Generator	1	85	85
QL165/1	QL165	QL Induction, (1) 165W lamp	Generator	1	165	165
		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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
HPS310/1	HPS310	High Pressure Sodium, (1) 310W lamp	CWA	1	310	365
HPS35/1	HPS35	High Pressure Sodium, (1) 35W lamp	CWA	1	35	46
HPS360/1	HPS360	High Pressure Sodium, (1) 360W lamp	CWA	1	360	414
HPS400/1	HPS400	High Pressure Sodium, (1) 400W lamp	CWA	1	400	465
HPS50/1	HPS50	High Pressure Sodium, (1) 50W lamp	CWA	1	50	66
HPS600/1	HPS600	High Pressure Sodium, (1) 600W lamp	CWA	1	600	675
HPS70/1	HPS70	High Pressure Sodium, (1) 70W lamp	CWA	1	70	95
HPS750/1	HPS750	High Pressure Sodium, (1) 750W lamp	CWA	1	750	835
		Metal Halide Fixtures				
MH100/1	MH100	Metal Halide, (1) 100W lamp	CWA	1	100	128
MH1000/1	MH1000	Metal Halide, (1) 1000W lamp	CWA	1	1000	1080
MH150/1	MH150	Metal Halide, (1) 150W lamp	CWA	1	150	190
MH1500/1	MH1500	Metal Halide, (1) 1500W lamp	CWA	1	1500	1610
MH175/1	MH175	Metal Halide, (1) 175W lamp	CWA	1	175	215
MH1800/1	MH1800	Metal Halide, (1) 1800W lamp	CWA	1	1800	1875
MH200/1	MH200	Metal Halide, (1) 200W lamp	CWA	1	200	232
MH250/1	MH250	Metal Halide, (1) 250W lamp	CWA	1	250	295
MH32/1	MH32	Metal Halide, (1) 32W lamp	CWA	1	32	43
MH300/1	MH300	Metal Halide, (1) 300W lamp	CWA	1	300	342
MH320/1	MH320	Metal Halide, (1) 320W lamp	CWA	1	320	365
MH350/1	MH350	Metal Halide, (1) 350W lamp	CWA	1	350	400
MH360/1	MH360	Metal Halide, (1) 360W lamp	CWA	1	360	430
MH400/1	MH400	Metal Halide, (1) 400W lamp	CWA	1	400	458
MH400/2	MH400	Metal Halide, (2) 400W lamp	CWA	2	400	916
MH450/1	MH450	Metal Halide, (1) 450W lamp	CWA	1	450	508

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
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
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

FIXTURE CODE	LAMP CODE	DESCRIPTION	BALLAST	Lamp/ fix	WATT/ LAMP	WATT/ FIXT
MHPS/SCWA/300/1	MHPS300	Metal Halide Pulse Start, (1) 300W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	300	342
MHPS/SCWA/320/1	MHPS320	Metal Halide Pulse Start, (1) 320W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	320	368
MHPS/SCWA/350/1	MHPS350	Metal Halide Pulse Start, (1) 350W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	350	400
MHPS/SCWA/400/1	MHPS400	Metal Halide Pulse Start, (1) 400W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	400	450
MHPS/SCWA/450/1	MHPS450	Metal Halide Pulse Start, (1) 450W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	450	506
MHPS/SCWA/750/1	MHPS750	Metal Halide Pulse Start, (1) 750W lamp w/ Super Constant Wattage Autotransformer Ballast	SCWA	1	750	815
		Mercury Vapor Fixtures				
MV100/1	MV100	Mercury Vapor, (1) 100W lamp	CWA	1	100	125
MV1000/1	MV1000	Mercury Vapor, (1) 1000W lamp	CWA	1	1000	1075
MV175/1	MV175	Mercury Vapor, (1) 175W lamp	CWA	1	175	205
MV250/1	MV250	Mercury Vapor, (1) 250W lamp	CWA	1	250	290
MV40/1	MV40	Mercury Vapor, (1) 40W lamp	CWA	1	40	50
MV400/1	MV400	Mercury Vapor, (1) 400W lamp	CWA	1	400	455
MV400/2	MV400	Mercury Vapor, (2) 400W lamp	CWA	2	400	910
MV50/1	MV50	Mercury Vapor, (1) 50W lamp	CWA	1	50	74
MV700/1	MV700	Mercury Vapor, (1) 700W lamp	CWA	1	700	780
MV75/1	MV75	Mercury Vapor, (1) 75W lamp	CWA	1	75	93

APPENDIX D. HVAC INTERACTIVE EFFECTS MULTIPLIERS

HVAC Interactive Effects Multipliers for 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

HVAC Interactive Effects Multipliers for Multifamily 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

HVAC Interactive Effects Multipliers for Multifamily High-rise

City	Fan coil with chiller and hot water boiler			Steam heat only		
	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Albany	0.080	0.113	-0.025	0.000	0.000	-0.028
Binghamton	0.068	0.073	-0.027	0.000	0.000	-0.030
Buffalo	0.072	0.113	-0.026	0.000	0.000	-0.029
Massena	0.073	0.094	-0.026	0.000	0.000	-0.029
NYC	0.101	0.194	-0.021	0.000	0.000	-0.024
Poughkeepsie	0.092	0.168	-0.023	0.000	0.000	-0.026
Syracuse	0.080	0.113	-0.024	0.000	0.000	-0.027

HVAC Interactive Effects Multipliers for Small Commercial Buildings

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
Assembly (Asy)	Albany	0.100	0.200	-0.031	-0.388	0.200	0.000	-0.536	0.200	0.000	-0.644	0.000	0.000	0.000	0.000	-0.032
	Binghamton	0.090	0.200	-0.036	-0.444	0.200	0.000	-0.676	0.200	0.000	-0.778	0.000	0.000	0.000	0.000	-0.036
	Buffalo	0.100	0.200	-0.034	-0.405	0.200	0.000	-0.645	0.200	0.000	-0.757	0.000	0.000	0.000	0.000	-0.036
	Massena	0.090	0.200	-0.041	-0.491	0.200	0.000	-0.653	0.200	0.000	-0.764	0.000	0.000	0.000	0.000	-0.037
	NYC	0.160	0.200	-0.021	-0.052	0.200	0.000	-0.243	0.200	0.000	-0.400	0.000	0.000	0.000	0.000	-0.020
	Poughkeepsie	0.130	0.200	-0.026	-0.361	0.200	0.000	-0.578	0.200	0.000	-0.700	0.000	0.000	0.000	0.000	-0.034
	Syracuse	0.110	0.200	-0.029	-0.364	0.200	0.000	-0.481	0.200	0.000	-0.610	0.000	0.000	0.000	0.000	-0.029
Auto repair (AR)	Albany	0.044	0.200	-0.032	-0.377	0.200	0.000	-0.630	0.200	0.000	-0.699	0.000	0.000	0.000	0.000	-0.032
	Binghamton	0.038	0.200	-0.028	-0.345	0.200	0.000	-0.564	0.200	0.000	-0.614	0.000	0.000	0.000	0.000	-0.028
	Buffalo	0.043	0.200	-0.033	-0.316	0.200	0.000	-0.661	0.200	0.000	-0.724	0.000	0.000	0.000	0.000	-0.033
	Massena	0.039	0.200	-0.033	-0.443	0.200	0.000	-0.653	0.200	0.000	-0.715	0.000	0.000	0.000	0.000	-0.033
	NYC	0.076	0.200	-0.041	-0.308	0.200	0.000	-0.795	0.200	0.000	-0.891	0.000	0.000	0.000	0.000	-0.042
	Poughkeepsie	0.057	0.200	-0.037	-0.408	0.200	0.000	-0.726	0.200	0.000	-0.811	0.000	0.000	0.000	0.000	-0.037
	Syracuse	0.046	0.200	-0.036	-0.394	0.200	0.000	-0.727	0.200	0.000	-0.809	0.000	0.000	0.000	0.000	-0.037
Big Box (BB)	Albany	0.120	0.200	-0.023	-0.166	0.200	0.000	-0.330	0.200	0.000	-0.458	0.000	0.000	0.000	0.000	-0.023
	Binghamton	0.110	0.200	-0.023	-0.172	0.200	0.000	-0.330	0.200	0.000	-0.462	0.000	0.000	0.000	0.000	-0.023
	Buffalo	0.110	0.200	-0.023	-0.163	0.200	0.000	-0.299	0.200	0.000	-0.424	0.000	0.000	0.000	0.000	-0.022
	Massena	0.100	0.200	-0.027	-0.298	0.200	0.000	-0.463	0.200	0.000	-0.572	0.000	0.000	0.000	0.000	-0.028
	NYC	0.170	0.200	-0.013	0.055	0.200	0.000	-0.065	0.200	0.000	-0.226	0.000	0.000	0.000	0.000	-0.013
	Poughkeepsie	0.145	0.200	-0.018	-0.085	0.200	0.000	-0.200	0.200	0.000	-0.350	0.000	0.000	0.000	0.000	-0.019
	Syracuse	0.120	0.200	-0.022	-0.144	0.200	0.000	-0.301	0.200	0.000	-0.425	0.000	0.000	0.000	0.000	-0.021
Elementary School (Elem)	Albany	0.060	0.200	-0.039	-0.399	0.200	0.000	-0.809	0.200	0.000	-0.916	0.000	0.000	0.000	0.000	-0.040
	Binghamton	0.040	0.200	-0.041	-0.406	0.200	0.000	-0.818	0.200	0.000	-0.950	0.000	0.000	0.000	0.000	-0.042
	Buffalo	0.040	0.200	-0.041	-0.382	0.200	0.000	-0.773	0.200	0.000	-0.908	0.000	0.000	0.000	0.000	-0.040
	Massena	0.040	0.200	-0.044	-0.509	0.200	0.000	-0.850	0.200	0.000	-0.963	0.000	0.000	0.000	0.000	-0.042
	NYC	0.110	0.200	-0.029	-0.150	0.200	0.000	-0.481	0.200	0.000	-0.646	0.000	0.000	0.000	0.000	-0.029
	Poughkeepsie	0.085	0.200	-0.034	-0.327	0.200	0.000	-0.743	0.200	0.000	-0.907	0.000	0.000	0.000	0.000	-0.040
	Syracuse	0.060	0.200	-0.039	-0.385	0.200	0.000	-0.778	0.200	0.000	-0.902	0.000	0.000	0.000	0.000	-0.040
Fast Food (FF)	Albany	0.070	0.200	-0.037	-0.702	0.200	0.000	-0.702	0.200	0.000	-0.818	0.000	0.000	0.000	0.000	-0.039
	Binghamton	0.060	0.200	-0.035	-0.732	0.200	0.000	-0.732	0.200	0.000	-0.808	0.000	0.000	0.000	0.000	-0.038
	Buffalo	0.070	0.200	-0.036	-0.677	0.200	0.000	-0.677	0.200	0.000	-0.815	0.000	0.000	0.000	0.000	-0.038
	Massena	0.070	0.200	-0.036	-0.717	0.200	0.000	-0.717	0.200	0.000	-0.814	0.000	0.000	0.000	0.000	-0.039
	NYC	0.110	0.200	-0.028	-0.471	0.200	0.000	-0.471	0.200	0.000	-0.827	0.000	0.000	0.000	0.000	-0.040
	Poughkeepsie	0.090	0.200	-0.033	-0.660	0.200	0.000	-0.660	0.200	0.000	-0.816	0.000	0.000	0.000	0.000	-0.039
	Syracuse	0.070	0.200	-0.035	-0.682	0.200	0.000	-0.682	0.200	0.000	-0.817	0.000	0.000	0.000	0.000	-0.039
Full	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

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
Service Restaurant (FS)	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
	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

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
	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
	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

HVAC Interactive Effects Multipliers for 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
	Massena	0.026	0.200	-0.022	0.012	0.200	-0.022	0.033	0.200	-0.017
	NYC	0.033	0.200	-0.022	0.019	0.200	-0.022	0.065	0.200	-0.013
	Poughkeepsie	0.029	0.200	-0.023	0.014	0.200	-0.023	0.053	0.200	-0.016
	Syracuse	0.029	0.200	-0.022	0.014	0.200	-0.022	0.054	0.200	-0.015

Building	City	CV Noecon			CV Econ			VAV Econ		
		HVACc	HVACd	HVACg	HVACc	HVACd	HVACg	HVACc	HVACd	HVACg
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

HVAC Interactive Effects Multipliers for 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

HVAC Interactive Effects Multipliers for 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

APPENDIX E. OPAQUE SHELL MEASURE SAVINGS

Single Family Residential Insulation Upgrades

Building: Single-Family Lowrise **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

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 Lowrise Insulation Upgrades

Building: Multi-Family Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise **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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise** **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 Lowrise** **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 Lowrise **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 Lowrise **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 Lowrise **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 Lowrise **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 Lowrise **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 Lowrise | **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 Lowrise **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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise 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 Lowrise **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 Lowrise **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 Lowrise 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 Lowrise 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 Lowrise **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 Highrise Insulation Upgrades

Building: Multi-Family Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Highrise 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 Lowrise 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 Highrise Infiltration Reduction

Savings for multi-family highrise buildings are normalized per 1000 SF of conditioned floor area treated by the air leakage sealing activity.

Impact per kSF

City	Vintage	kWh/ 1000 SF	kW/ 1000SF	Therm/ 1000SF
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	0.030	0
	AC with gas heat	34	0.030	43.2
	Air source heat pump	768	0.030	0
	Electric heat only	979	0.000	0
	Gas heat only	0	0.000	43.3
Binghamton	AC with electric heat	964	0.030	0
	AC with gas heat	30	0.030	43.3
	Air source heat pump	843	0.030	0
	Electric heat only	961	0.000	0
	Gas heat only	0	0.000	44.2
Buffalo	AC with electric heat	920	0.030	0
	AC with gas heat	25	0.030	41.5
	Air source heat pump	674	0.030	0
	Electric heat only	916		0
	Gas heat only	0	0.000	42
Massena	AC with electric heat	1,823	0.030	0
	AC with gas heat	54	0.030	82.1
	Air source heat pump	1,442	0.030	0
	Electric heat only	1,842	0.000	0
	Gas heat only	0	0.000	84.3
NYC	AC with electric heat	425	0.030	0
	AC with gas heat	37	0.030	18.4
	Air source heat pump	248	0.030	0
	Electric heat only	405	0.000	0
	Gas heat only	0	0.000	20.4
Poughkeepsie	AC with electric heat	1,005	0.030	0.1
	AC with gas heat	36	0.030	44.3
	Air source heat pump	778	0.030	0
	Electric heat only	991	0.000	0
	Gas heat only	0	0.000	44.7
Syracuse	AC with electric heat	789	0.030	0
	AC with gas heat	30	0.030	35.1
	Air source heat pump	789	0.030	0
	Electric heat only	778	0.000	0
	Gas heat only	0	0.000	36.1

Roof Insulation - Auto Repair

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	564	0.030	0
	AC with gas heat	32	0.030	25.2
	Air source heat pump	407	0.030	0
	Electric heat only	524	0.000	0
	Gas heat only	0	0.000	24.1
Binghamton	AC with electric heat	489	0.030	0
	AC with gas heat	24	0.030	21.7
	Air source heat pump	316	0.030	0
	Electric heat only	441	0.000	0
	Gas heat only	0	0.000	20
Buffalo	AC with electric heat	500	0.030	0
	AC with gas heat	23	0.030	20.8
	Air source heat pump	315	0.030	0
	Electric heat only	490	0.000	0
	Gas heat only	0	0.000	20.6
Massena	AC with electric heat	585	0.030	0
	AC with gas heat	32	0.030	25.8
	Air source heat pump	377	0.030	0
	Electric heat only	564	0.000	0
	Gas heat only	0	0.000	25.6
N YC	AC with electric heat	915	0.030	0
	AC with gas heat	56	0.030	41.2
	Air source heat pump	431	0.030	0
	Electric heat only	882	0.000	0
	Gas heat only	0	0.000	40.6
Poughkeepsie	AC with electric heat	754	0.030	0
	AC with gas heat	41	0.030	33.4
	Air source heat pump	532	0.030	0
	Electric heat only	748	0.000	0
	Gas heat only	0	0.000	33.8
Syracuse	AC with electric heat	584	0.030	0
	AC with gas heat	34	0.030	26.4
	Air source heat pump	423	0.030	0
	Electric heat only	593	0.000	0
	Gas heat only	0	0.000	27.6

Roof Insulation - Big Box Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	847	0.030	0
	AC with gas heat	33	0.030	42.5
	Air source heat pump	682	0.030	0
	Electric heat only	895	0.000	0
	Gas heat only	0	0.000	43.5
Binghamton	AC with electric heat	740	0.030	0
	AC with gas heat	23	0.030	38.2
	Air source heat pump	604	0.030	0
	Electric heat only	800	0.000	0
	Gas heat only	0	0.000	40.1
Buffalo	AC with electric heat	707	0.030	0
	AC with gas heat	22	0.030	36.3
	Air source heat pump	509	0.030	0
	Electric heat only	774	0.000	0
	Gas heat only	0	0.000	38.2
Massena	AC with electric heat	1213	0.030	0
	AC with gas heat	37	0.030	59.2
	Air source heat pump	1072	0.030	0
	Electric heat only	1263	0.000	0
	Gas heat only	0	0.000	60.7
NYC	AC with electric heat	290	0.030	0
	AC with gas heat	37	0.030	17.1
	Air source heat pump	141	0.030	0
	Electric heat only	341	0.000	0
	Gas heat only	0	0.000	19
Poughkeepsie	AC with electric heat	615	0.030	0
	AC with gas heat	32	0.030	32.2
	Air source heat pump	536	0.030	0
	Electric heat only	680	0.000	0
	Gas heat only	0	0.000	33.9
Syracuse	AC with electric heat	751	0.030	0
	AC with gas heat	32	0.030	38.1
	Air source heat pump	534	0.030	0
	Electric heat only	810	0.000	0
	Gas heat only	0	0.000	40.3

Roof Insulation - Fast Food Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1009	0.030	0
	AC with gas heat	38	0.030	45.5
	Air source heat pump	716	0.030	0
	Electric heat only	993	0.000	0
	Gas heat only	0	0.000	46
Binghamton	AC with electric heat	999	0.030	0
	AC with gas heat	30	0.030	45.5
	Air source heat pump	709	0.030	0
	Electric heat only	1023	0.000	0
	Gas heat only	0	0.000	47
Buffalo	AC with electric heat	1066	0.030	0
	AC with gas heat	36	0.030	48
	Air source heat pump	757	0.030	0
	Electric heat only	1036		0
	Gas heat only	0	0.000	47
Massena	AC with electric heat	1055	0.030	0
	AC with gas heat	33	0.030	47
	Air source heat pump	749	0.030	0
	Electric heat only	1074	0.000	0
	Gas heat only	0	0.000	49.5
NYC	AC with electric heat	755	0.030	0
	AC with gas heat	61	0.030	34
	Air source heat pump	536	0.030	0
	Electric heat only	988	0.000	0
	Gas heat only	0	0.000	46.5
Poughkeepsie	AC with electric heat	994	0.030	0
	AC with gas heat	47	0.030	45.5
	Air source heat pump	706	0.030	0
	Electric heat only	994	0.000	0
	Gas heat only	0	0.000	46
Syracuse	AC with electric heat	1023	0.030	0
	AC with gas heat	43	0.030	46.5
	Air source heat pump	726	0.030	0
	Electric heat only	1097	0.000	0
	Gas heat only	0	0.000	50.5

Roof Insulation - Full Service Restaurant

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	946	0.030	0
	AC with gas heat	51	0.030	42.8
	Air source heat pump	672	0.030	0
	Electric heat only	941	0.000	0
	Gas heat only	0	0.000	43.3
Binghamton	AC with electric heat	789	0.030	0
	AC with gas heat	42	0.030	35
	Air source heat pump	560	0.030	0
	Electric heat only	790	0.000	0
	Gas heat only	0	0.000	35.5
Buffalo	AC with electric heat	832	0.030	0
	AC with gas heat	43	0.030	37.8
	Air source heat pump	591	0.030	0
	Electric heat only	797		0
	Gas heat only	0	0.000	36.8
Massena	AC with electric heat	944	0.030	0
	AC with gas heat	54	0.030	42.5
	Air source heat pump	670	0.030	0
	Electric heat only	926	0.000	0
	Gas heat only	0	0.000	42.5
NYC	AC with electric heat	698	0.030	0
	AC with gas heat	53	0.030	32
	Air source heat pump	496	0.030	0
	Electric heat only	688	0.000	0
	Gas heat only	0	0.000	32.3
Poughkeepsie	AC with electric heat	852	0.030	0
	AC with gas heat	57	0.030	39.5
	Air source heat pump	605	0.030	0
	Electric heat only	841	0.000	0
	Gas heat only	0	0.000	39.8
Syracuse	AC with electric heat	915	0.030	0
	AC with gas heat	55	0.030	41.5
	Air source heat pump	650	0.030	0
	Electric heat only	930	0.000	0
	Gas heat only	0	0.000	43

Roof Insulation – Grocery

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	847	0.030	0
	AC with gas heat	33	0.030	42.5
	Air source heat pump	682	0.030	0
	Electric heat only	895	0.000	0
	Gas heat only	0	0.000	43.5
Binghamton	AC with electric heat	740	0.030	0
	AC with gas heat	23	0.030	38.2
	Air source heat pump	604	0.030	0
	Electric heat only	800	0.000	0
	Gas heat only	0	0.000	40.1
Buffalo	AC with electric heat	707	0.030	0
	AC with gas heat	22	0.030	36.3
	Air source heat pump	509	0.030	0
	Electric heat only	774	0.000	0
	Gas heat only	0	0.000	38.2
Massena	AC with electric heat	1213	0.030	0
	AC with gas heat	37	0.030	59.2
	Air source heat pump	1072	0.030	0
	Electric heat only	1263	0.000	0
	Gas heat only	0	0.000	60.7
NYC	AC with electric heat	290	0.030	0
	AC with gas heat	37	0.030	17.1
	Air source heat pump	141	0.030	0
	Electric heat only	341	0.000	0
	Gas heat only	0	0.000	19
Poughkeepsie	AC with electric heat	615	0.030	0
	AC with gas heat	32	0.030	32.2
	Air source heat pump	536	0.030	0
	Electric heat only	680	0.000	0
	Gas heat only	0	0.000	33.9
Syracuse	AC with electric heat	751	0.030	0
	AC with gas heat	32	0.030	38.1
	Air source heat pump	534	0.030	0
	Electric heat only	810	0.000	0
	Gas heat only	0	0.000	40.3

Roof Insulation – Light Industrial

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	929	0.030	0.0
Albany	AC with gas heat	45	0.030	44.1
Albany	Air source heat pump	585	0.030	0.0
Albany	Electric heat only	937	0.000	0.0
Albany	Gas heat only	0	0.000	44.1
Binghamton	AC with electric heat	968	0.030	0.0
Binghamton	AC with gas heat	46	0.030	45.9
Binghamton	Air source heat pump	602	0.030	0.0
Binghamton	Electric heat only	976	0.000	0.0
Binghamton	Gas heat only	0	0.000	45.9
Buffalo	AC with electric heat	930	0.030	0.0
Buffalo	AC with gas heat	44	0.030	44.2
Buffalo	Air source heat pump	570	0.030	0.0
Buffalo	Electric heat only	940	0.000	0.0
Buffalo	Gas heat only	0	0.000	44.2
Massena	AC with electric heat	1079	0.030	0.0
Massena	AC with gas heat	48	0.030	50.8
Massena	Air source heat pump	725	0.030	0.0
Massena	Electric heat only	1088	0.000	0.0
Massena	Gas heat only	0	0.000	50.9
NYC	AC with electric heat	655	0.030	0.0
NYC	AC with gas heat	55	0.030	30.9
NYC	Air source heat pump	345	0.030	0.0
NYC	Electric heat only	647	0.000	0.0
NYC	Gas heat only	0	0.000	30.6
Poughkeepsie	AC with electric heat	829	0.030	0.0
Poughkeepsie	AC with gas heat	48	0.030	39.5
Poughkeepsie	Air source heat pump	504	0.030	0.0
Poughkeepsie	Electric heat only	834	0.000	0.0
Poughkeepsie	Gas heat only	0	0.000	39.5
Syracuse	AC with electric heat	923	0.030	0.0
Syracuse	AC with gas heat	50	0.030	43.6
Syracuse	Air source heat pump	579	0.030	0.0
Syracuse	Electric heat only	927	0.000	0.0
Syracuse	Gas heat only	0	0.000	43.5

Roof Insulation – Motel

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with gas heat	264	0.030	0
Albany	AC with electric heat	37	0.030	12.9
Albany	Air source heat pump	235	0.030	0
Albany	Electric heat only	273	0.000	0
Albany	Gas heat only	0	0.000	13.1
Buffalo	AC with gas heat	276	0.030	0
Buffalo	AC with electric heat	31	0.030	13.6
Buffalo	Air source heat pump	245	0.030	0
Buffalo	Electric heat only	289	0.000	0
Buffalo	Gas heat only	0	0.000	13.9
Massena	AC with gas heat	265	0.030	0
Massena	AC with electric heat	30	0.030	13.2
Massena	Air source heat pump	235	0.030	0
Massena	Electric heat only	278	0.000	0
Massena	Gas heat only	0	0.000	13.2
NYC	AC with gas heat	315	0.030	0
NYC	AC with electric heat	42	0.030	15.3
NYC	Air source heat pump	293	0.030	0
NYC	Electric heat only	323	0.000	0
NYC	Gas heat only	0	0.000	15.3
Syracuse	AC with gas heat	176	0.030	0
Syracuse	AC with electric heat	48	0.030	8.6
Syracuse	Air source heat pump	140	0.030	0
Syracuse	Electric heat only	183	0.000	0
Syracuse	Gas heat only	0	0.000	8.8
Binghamton	AC with gas heat	221	0.030	0
Binghamton	AC with electric heat	41	0.030	10.9
Binghamton	Air source heat pump	188	0.030	0
Binghamton	Electric heat only	230	0.000	0
Binghamton	Gas heat only	0	0.000	11.1
Poughkeepsie	AC with gas heat	268	0.030	0
Poughkeepsie	AC with electric heat	39	0.030	12.7
Poughkeepsie	Air source heat pump	242	0.030	0
Poughkeepsie	Electric heat only	271	0.000	0
Poughkeepsie	Gas heat only	0	0.000	12.9

Roof Insulation - Elementary School

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1456	0.030	0
	AC with gas heat	121	0.030	59.9
	Air source heat pump	916	0.030	0
	Electric heat only	1411	0.000	0
	Gas heat only	0	0.000	59.8
Binghamton	AC with electric heat	1369	0.030	0
	AC with gas heat	110	0.030	56.6
	Air source heat pump	813	0.030	0
	Electric heat only	1337	0.000	0
	Gas heat only	0	0.000	56.4
Buffalo	AC with electric heat	1366	0.030	0
	AC with gas heat	107	0.030	56.7
	Air source heat pump	831	0.030	0
	Electric heat only	1345	0.000	0
	Gas heat only	0	0.000	56.8
Massena	AC with electric heat	1560	0.030	0
	AC with gas heat	121	0.030	64.1
	Air source heat pump	1030	0.030	0
	Electric heat only	1519	0.000	0
	Gas heat only	0	0.000	64
NYC	AC with electric heat	1072	0.030	0
	AC with gas heat	146	0.030	43.1
	Air source heat pump	550	0.030	0
	Electric heat only	1000	0.000	0
	Gas heat only	0	0.000	42.5
Poughkeepsie	AC with electric heat	1371	0.030	0
	AC with gas heat	142	0.030	56.1
	Air source heat pump	842	0.030	0
	Electric heat only	1332	0.000	0
	Gas heat only	0	0.000	56.5
Syracuse	AC with electric heat	1326	0.030	0
	AC with gas heat	123	0.030	54.3
	Air source heat pump	799	0.030	0
	Electric heat only	1267	0.000	0
	Gas heat only	0	0.000	53.6

Roof Insulation – Religious Worship

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	994	0.030	0
	AC with gas heat	34	0.030	43.2
	Air source heat pump	768	0.030	0
	Electric heat only	979	0.000	0
	Gas heat only	0	0.000	43.3
Binghamton	AC with electric heat	964	0.030	0
	AC with gas heat	30	0.030	43.3
	Air source heat pump	843	0.030	0
	Electric heat only	961	0.000	0
	Gas heat only	0	0.000	44.2
Buffalo	AC with electric heat	920	0.030	0
	AC with gas heat	25	0.030	41.5
	Air source heat pump	674	0.030	0
	Electric heat only	916	0.000	0
	Gas heat only	0	0.000	42
Massena	AC with electric heat	1,823	0.030	0
	AC with gas heat	54	0.030	82.1
	Air source heat pump	1,442	0.030	0
	Electric heat only	1,842	0.000	0
	Gas heat only	0	0.000	84.3
NYC	AC with electric heat	425	0.030	0
	AC with gas heat	37	0.030	18.4
	Air source heat pump	248	0.030	0
	Electric heat only	405	0.000	0
	Gas heat only	0	0.000	20.4
Poughkeepsie	AC with electric heat	1,005	0.030	0
	AC with gas heat	36	0.030	44.3
	Air source heat pump	778	0.030	0
	Electric heat only	991	0.000	0
	Gas heat only	0	0.000	44.7
Syracuse	AC with electric heat	789	0.030	0
	AC with gas heat	30	0.030	35.1
	Air source heat pump	789	0.030	0
	Electric heat only	778	0.000	0
	Gas heat only	0	0.000	36.1

Roof Insulation – Small Office

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	649	0.030	0.0
	AC with gas heat	28	0.030	31.0
	Air source heat pump	412	0.030	0.0
	Electric heat only	631	0.000	0.0
	Gas heat only	0	0.000	30.4
Binghamton	AC with electric heat	670	0.030	0.0
	AC with gas heat	25	0.030	32.0
	Air source heat pump	416	0.030	0.0
	Electric heat only	652	0.000	0.2
	Gas heat only	0	0.000	31.2
Buffalo	AC with electric heat	652	0.030	0.0
	AC with gas heat	25	0.030	31.2
	Air source heat pump	402	0.030	0.0
	Electric heat only	644	0.000	0.0
	Gas heat only	0	0.000	31.0
Massena	AC with electric heat	788	0.030	0.0
	AC with gas heat	34	0.030	36.8
	Air source heat pump	551	0.030	0.0
	Electric heat only	777	0.000	0.0
	Gas heat only	0	0.000	37.2
NYC	AC with electric heat	430	0.030	0.0
	AC with gas heat	37	0.030	20.0
	Air source heat pump	227	0.030	0.0
	Electric heat only	384	0.000	0.0
	Gas heat only	0	0.000	19.6
Poughkeepsie	AC with electric heat	555	0.030	0.0
	AC with gas heat	31	0.030	26.4
	Air source heat pump	347	0.030	0.0
	Electric heat only	539	0.000	0.0
	Gas heat only	0	0.000	26.2
Syracuse	AC with electric heat	640	0.030	0.0
	AC with gas heat	33	0.030	30.2
	Air source heat pump	401	0.030	0.0
	Electric heat only	623	0.000	0.0
	Gas heat only	0	0.000	30.0

Roof Insulation – Small Retail

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1013	0.030	0
	AC with gas heat	60	0.030	47.2
	Air source heat pump	671	0.030	0
	Electric heat only	977	0.000	0
	Gas heat only	0	0.000	46.4
Binghamton	AC with electric heat	1005	0.030	0
	AC with gas heat	50	0.030	47.3
	Air source heat pump	659	0.030	0
	Electric heat only	987	0.000	0
	Gas heat only	0	0.000	46.9
Buffalo	AC with electric heat	998	0.030	0
	AC with gas heat	53	0.030	46.9
	Air source heat pump	602	0.030	0
	Electric heat only	982	0.000	0
	Gas heat only	0	0.000	46.9
Massena	AC with electric heat	1174	0.030	0
	AC with gas heat	63	0.030	54.5
	Air source heat pump	792	0.030	0
	Electric heat only	1152	0.000	0
	Gas heat only	0	0.000	54.1
NYC	AC with electric heat	678	0.030	0
	AC with gas heat	66	0.030	31.6
	Air source heat pump	362	0.030	0
	Electric heat only	625	0.000	0
	Gas heat only	0	0.000	30.6
Poughkeepsie	AC with electric heat	836	0.030	0
	AC with gas heat	54	0.030	39.4
	Air source heat pump	511	0.030	0
	Electric heat only	800	0.000	0
	Gas heat only	0	0.000	38.4
Syracuse	AC with electric heat	1026	0.030	0
	AC with gas heat	65	0.030	48
	Air source heat pump	660	0.030	0
	Electric heat only	1006	0.000	0
	Gas heat only	0	0.000	47.8

Roof Insulation – Warehouse

Climate	System	kWh/unit	Summer kW/unit	therm/unit
Albany	AC with electric heat	1631	0.030	0
	AC with gas heat	13	0.030	65.6
	Air source heat pump	1215	0.030	0
	Electric heat only	1614	0.000	0
	Gas heat only	0	0.000	65.3
Binghamton	AC with electric heat	1656	0.030	0
	AC with gas heat	5	0.030	66.7
	Air source heat pump	1228	0.030	0
	Electric heat only	1650	0.000	0
	Gas heat only	0	0.000	66.7
Buffalo	AC with electric heat	1584	0.030	0
	AC with gas heat	0	0.030	64.2
	Air source heat pump	1141	0.030	0
	Electric heat only	1585	0.000	0
	Gas heat only	0	0.000	64.2
Massena	AC with electric heat	1522	0.030	0
	AC with gas heat	22	0.030	60.4
	Air source heat pump	1083	0.030	0
	Electric heat only	1501	0.000	0
	Gas heat only	0	0.000	60.5
NYC	AC with electric heat	1468	0.030	0
	AC with gas heat	48	0.030	60.3
	Air source heat pump	925	0.030	0
	Electric heat only	1416	0.000	0
	Gas heat only	0	0.000	60.1
Poughkeepsie	AC with electric heat	1612	0.030	0
	AC with gas heat	26	0.030	65.8
	Air source heat pump	1004	0.030	0
	Electric heat only	1586	0.000	0
	Gas heat only	0	0.000	65.8
Syracuse	AC with electric heat	1817	0.030	0
	AC with gas heat	21	0.030	72.4
	Air source heat pump	1409	0.030	0
	Electric heat only	1796	0.000	0
	Gas heat only	0	0.000	72.5

APPENDIX F. WINDOW AND HIGH PERFORMANCE GLAZING

Single Family Residential Energy Star Window Upgrades

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

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	125.5	0.117	9.2	252.7	0.124	336.0	0.117	4.0	0.000	9.1	214.6	0.000
2 pane	64.5	0.060	1.6	98.7	0.060	106.3	0.060	0.5	0.000	1.5	42.4	0.000
Code	1.1	0.003	2.7	27.4	0.003	59.9	0.003	1.3	0.000	2.7	60.2	0.000

Syracuse

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	94.5	0.091	18.4	396.4	0.101	510.4	0.091	8.7	0.000	18.3	424.6	0.000
2 pane	47.6	0.064	6.0	153.9	0.067	185.3	0.064	2.6	0.000	5.9	140.4	0.000
Code	1.1	0.003	3.7	48.6	0.000	81.0	0.003	1.8	0.000	3.7	81.8	0.000

Binghamton

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	75.7	0.104	19.3	420.4	0.107	517.5	0.104	9.3	0.000	19.2	451.1	0.000
2 pane	36.2	0.054	6.1	156.3	0.054	177.3	0.054	2.6	0.000	6.0	143.8	0.000
Code	1.6	0.003	3.9	56.8	0.003	88.2	0.003	2.1	0.000	3.9	88.6	0.000

Poughkeepsie

Baseline	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh	kW	Therm	kWh	kW	kWh	kW	kWh	kW	Therm	kWh	kW
1 pane	86.6	0.104	11.9	277.1	0.117	359.1	0.104	5.5	0.000	11.8	277.8	0.000
2 pane	44.0	0.054	3.2	109.2	0.060	121.1	0.054	1.3	0.000	3.1	78.4	0.000
Code	1.4	0.000	3.4	38.8	0.000	72.3	0.000	1.6	0.000	3.4	72.6	0.000

Multifamily Low-rise Energy Star Window Upgrades

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

	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	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

	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	147.7	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

	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	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 Peformance 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
	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
	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
	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
	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
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
	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
	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

APPENDIX G. HEATING AND COOLING EQUIVALENT FULL-LOAD HOURS

Cooling 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. Residential prototypes for three different classes of building vintage were developed:

1. Old, poorly insulated buildings constructed before 1979, before the NY State Energy Code went into effect. This vintage is referred to as the “old” vintage.
2. Existing, average insulated buildings conforming to 1980s era building codes. This vintage is referred to as the “average” vintage.
3. New construction conforming to the 2007 Energy Conservation Code of New York State for residential buildings. This vintage is referred to as the “new” vintage.

The cooling EFLH are shown below:

Single Family Detached Cooling Equivalent full load hours 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

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

City	Old	Average	New
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

Multifamily High-Rise Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Fan coil	594	479	572	532	793	626	592

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 Equivalent full load hours 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

Multifamily Low-Rise Heating Equivalent full load hours by Vintage and City

City	Old	Average	New
Albany	1,030	1,012	729
Binghamton	1,320	1,245	899
Buffalo	1,219	1,215	883
Massena	1,306	1,326	964
NYC	757	723	503
Poughkeepsie	894	868	616
Syracuse	1,175	1,206	845

Multifamily High-Rise Heating EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
FC	786	1006	966	1016	526	656	889

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

Office Building Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	1,894	1,786	2,016	1,827	2,250	2,072	2,156
CAV econ	706	534	587	610	720	713	667
VAV econ	623	519	504	505	716	670	572

Hospital Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	1,728	1,662	1,908	1,730	2,237	1,983	1,906
CAV econ	1,038	918	1,114	1,038	1,424	1,231	1,147
VAV econ	961	855	1,026	962	1,217	1,089	1,050

Community College Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	773	586	693	692	1128	997	811
CAV econ	585	433	520	509	846	706	609
VAV econ	470	376	456	353	658	532	455

Dormitory Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
Fan coil	736	657	752	693	800	760	763

Hotel Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	2945	3270	2945	3021	3108	3253	3653
CAV econ	2744	3078	2744	2807	2918	3039	3471
VAV econ	2702	3046	2702	2745	2929	2937	3437

Large Retail Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	1656	1613	1763	1545	1751	1670	1656
CAV econ	858	721	849	753	1068	920	858
VAV econ	704	594	713	611	886	757	704

University Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	936	723	870	811	1208	1030	951
CAV econ	680	496	610	567	882	706	699
VAV econ	526	432	518	413	690	568	523

High School Cooling EFLH

System	Albany	Binghamton	Buffalo	Massena	NYC	Poughkeepsie	Syracuse
CAV no econ	713	727	741	727	861	787	764
CAV econ	348	304	323	318	466	407	388
VAV econ	237	203	215	215	341	289	256

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

APPENDIX H. 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	Buffalo	Massena	NYC	Syracuse	Binghamton	Poughkeepsie
8%	Uninsulated	0.777	0.770	0.759	0.818	0.778	0.754	0.779
15%	Uninsulated	0.715	0.708	0.693	0.761	0.716	0.692	0.717
20%	Uninsulated	0.668	0.662	0.644	0.717	0.670	0.646	0.671
25%	Uninsulated	0.619	0.614	0.592	0.673	0.622	0.599	0.623
30%	Uninsulated	0.568	0.564	0.539	0.626	0.571	0.549	0.573
8%	R-6	0.910	0.910	0.905	0.920	0.911	0.907	0.911
15%	R-7	0.851	0.851	0.843	0.865	0.852	0.848	0.851
20%	R-8	0.806	0.807	0.796	0.823	0.808	0.804	0.807
25%	R-9	0.760	0.762	0.748	0.780	0.762	0.759	0.761
30%	R-10	0.712	0.715	0.698	0.735	0.714	0.711	0.714

Residential Distribution System Efficiency in Cooling Mode (Attic Ducts)

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Buffalo	Massena	NYC	Syracuse	Binghamton	Poughkeepsie
8%	Uninsulated	0.813	0.820	0.809	0.834	0.811	0.793	0.810
15%	Uninsulated	0.755	0.768	0.753	0.777	0.758	0.737	0.753
20%	Uninsulated	0.716	0.732	0.715	0.737	0.717	0.698	0.713
25%	Uninsulated	0.676	0.694	0.673	0.696	0.677	0.660	0.672
30%	Uninsulated	0.637	0.656	0.634	0.657	0.637	0.621	0.632
8%	R-6	0.916	0.922	0.916	0.919	0.918	0.914	0.916
15%	R-7	0.860	0.870	0.859	0.861	0.862	0.860	0.861
20%	R-8	0.821	0.833	0.819	0.823	0.821	0.820	0.821
25%	R-9	0.780	0.795	0.781	0.782	0.783	0.780	0.780
30%	R-10	0.740	0.761	0.739	0.741	0.742	0.740	0.739

Multifamily 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

Multifamily 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

APPENDIX I. COOL ROOF

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Assembly	Albany	1000 sq ft roof area	138	0.128	-16.0
	Binghamton	1000 sq ft roof area	123	0.128	-16.0
	Buffalo	1000 sq ft roof area	119	0.128	-16.0
	Massena	1000 sq ft roof area	135	0.128	-19.0
	NYC	1000 sq ft roof area	168	0.128	-11.0
	Poughkeepsie	1000 sq ft roof area	163	0.128	-13.5
	Syracuse	1000 sq ft roof area	150	0.128	-18.0
Auto Repair	Albany	1000 sq ft roof area	77	0.128	-23.0
	Binghamton	1000 sq ft roof area	66	0.128	-20.2
	Buffalo	1000 sq ft roof area	65	0.128	-20.0
	Massena	1000 sq ft roof area	78	0.128	-23.3
	NYC	1000 sq ft roof area	116	0.128	-20.8
	Poughkeepsie	1000 sq ft roof area	95	0.128	-21.9
	Syracuse	1000 sq ft roof area	89	0.128	-21.9
Big Box Retail	Albany	1000 sq ft roof area	155	0.128	-11.0
	Binghamton	1000 sq ft roof area	146	0.128	-10.5
	Buffalo	1000 sq ft roof area	132	0.128	-10.0
	Massena	1000 sq ft roof area	150	0.128	-14.0
	NYC	1000 sq ft roof area	187	0.128	-6.0
	Poughkeepsie	1000 sq ft roof area	183	0.128	-8.5
	Syracuse	1000 sq ft roof area	165	0.128	-12.0
Fast Food	Albany	1000 sq ft roof area	117	0.128	-28.0
	Binghamton	1000 sq ft roof area	101	0.128	-26.0
	Buffalo	1000 sq ft roof area	101	0.128	-24.0
	Massena	1000 sq ft roof area	124	0.128	-25.0
	NYC	1000 sq ft roof area	170	0.128	-19.0
	Poughkeepsie	1000 sq ft roof area	143	0.128	-23.5
	Syracuse	1000 sq ft roof area	131	0.128	-28.0
Full Service Restaurant	Albany	1000 sq ft roof area	279	0.128	-47.0
	Binghamton	1000 sq ft roof area	112	0.128	-43.5
	Buffalo	1000 sq ft roof area	233	0.128	-40.0
	Massena	1000 sq ft roof area	282	0.128	-47.0
	NYC	1000 sq ft roof area	344	0.128	-30.0
	Poughkeepsie	1000 sq ft roof area	160	0.128	-38.5
	Syracuse	1000 sq ft roof area	307	0.128	-47.0

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Grocery	Albany	1000 sq ft roof area	155	0.128	-11.0
	Binghamton	1000 sq ft roof area	146	0.128	-10.5
	Buffalo	1000 sq ft roof area	132	0.128	-10.0
	Massena	1000 sq ft roof area	150	0.128	-14.0
	NYC	1000 sq ft roof area	187	0.128	-6.0
	Poughkeepsie	1000 sq ft roof area	183	0.128	-8.5
	Syracuse	1000 sq ft roof area	165	0.128	-12.0
Light Industrial	Albany	1000 sq ft roof area	90	0.128	-20.0
	Binghamton	1000 sq ft roof area	62	0.128	-19.0
	Buffalo	1000 sq ft roof area	74	0.128	-18.0
	Massena	1000 sq ft roof area	87	0.128	-21.0
	NYC	1000 sq ft roof area	118	0.128	-14.0
	Poughkeepsie	1000 sq ft roof area	94	0.128	-17.0
	Syracuse	1000 sq ft roof area	102	0.128	-20.0
Motel	Albany	1000 sq ft roof area	225	0.128	-10.0
	Binghamton	1000 sq ft roof area	196	0.128	-8.8
	Buffalo	1000 sq ft roof area	224	0.128	-11.3
	Massena	1000 sq ft roof area	238	0.128	-6.3
	NYC	1000 sq ft roof area	232	0.128	-10.9
	Poughkeepsie	1000 sq ft roof area	207	0.128	-11.1
	Syracuse	1000 sq ft roof area	250	0.128	-11.0
Primary School	Albany	1000 sq ft roof area	196	0.624	-29.0
	Binghamton	1000 sq ft roof area	145	0.086	-28.0
	Buffalo	1000 sq ft roof area	152	0.426	-27.0
	Massena	1000 sq ft roof area	191	0.116	-32.0
	NYC	1000 sq ft roof area	270	0.652	-22.0
	Poughkeepsie	1000 sq ft roof area	225	0.474	-25.5
	Syracuse	1000 sq ft roof area	202	0.506	-33.0
Religious	Albany	1000 sq ft roof area	138	0.128	-16.0
	Binghamton	1000 sq ft roof area	123	0.128	-18.0
	Buffalo	1000 sq ft roof area	120	0.128	-15.6
	Massena	1000 sq ft roof area	135	0.128	-19.5
	NYC	1000 sq ft roof area	168	0.128	-10.3
	Poughkeepsie	1000 sq ft roof area	163	0.128	-19.7
	Syracuse	1000 sq ft roof area	150	0.128	-18.8

Building Type	City	Unit	KWh/unit	KW/unit	Therm/unit
Small Office	Albany	1000 sq ft roof area	151	0.128	-12.0
	Binghamton	1000 sq ft roof area	128	0.128	-11.5
	Buffalo	1000 sq ft roof area	130	0.128	-11.0
	Massena	1000 sq ft roof area	152	0.128	-14.0
	NYC	1000 sq ft roof area	169	0.128	-8.0
	Poughkeepsie	1000 sq ft roof area	164	0.128	-10.0
	Syracuse	1000 sq ft roof area	157	0.128	-14.0
Small Retail	Albany	1000 sq ft roof area	175	0.128	-17.0
	Binghamton	1000 sq ft roof area	160	0.128	-16.0
	Buffalo	1000 sq ft roof area	143	0.128	-15.0
	Massena	1000 sq ft roof area	164	0.128	-21.0
	NYC	1000 sq ft roof area	203	0.128	-12.0
	Poughkeepsie	1000 sq ft roof area	195	0.128	-14.5
	Syracuse	1000 sq ft roof area	184	0.128	-18.0
Warehouse	Albany	1000 sq ft roof area	393	0.128	-48.4
	Binghamton	1000 sq ft roof area	324	0.128	-56.4
	Buffalo	1000 sq ft roof area	300	0.128	-44.7
	Massena	1000 sq ft roof area	402	0.128	-47.4
	NYC	1000 sq ft roof area	454	0.128	-38.6
	Poughkeepsie	1000 sq ft roof area	464	0.128	-63.7
	Syracuse	1000 sq ft roof area	440	0.128	-52.2
Other	Albany	1000 sq ft roof area	188	0.128	*-25.0*
	Binghamton	1000 sq ft roof area	142	0.128	-21.9
	Buffalo	1000 sq ft roof area	149	0.128	-20.2
	Massena	1000 sq ft roof area	175	0.128	-23.0
	NYC	1000 sq ft roof area	211	0.128	-16.7
	Poughkeepsie	1000 sq ft roof area	188	0.128	-21.0
	Syracuse	1000 sq ft roof area	193	0.128	-23.3

APPENDIX J. COMMERCIAL HVAC UNIT SAVINGS

Air Side Economizer

Building Type	City	unit	KWh/unit
Assembly	Albany	ton	39
	Binghamton	ton	36
	Buffalo	ton	45
	Massena	ton	33
	NYC	ton	27
	Syracuse	ton	42
	Poughkeepsie	ton	33
Big Box Retail	Albany	ton	165
	Binghamton	ton	152
	Buffalo	ton	167
	Massena	ton	138
	NYC	ton	152
	Syracuse	ton	165
	Poughkeepsie	ton	159
Fast Food	Albany	ton	49
	Binghamton	ton	47
	Buffalo	ton	53
	Massena	ton	44
	NYC	ton	39
	Syracuse	ton	49
	Poughkeepsie	ton	44
Full Service Restaurant	Albany	ton	38
	Binghamton	ton	35
	Buffalo	ton	41
	Massena	ton	32
	NYC	ton	31
	Syracuse	ton	38
	Poughkeepsie	ton	35

Building Type	City	unit	KWh/unit
Light Industrial	Albany	ton	45
	Binghamton	ton	39
	Buffalo	ton	38
	Massena	ton	33
	NYC	ton	25
	Syracuse	ton	54
	Poughkeepsie	ton	35
Primary School	Albany	ton	49
	Binghamton	ton	44
	Buffalo	ton	52
	Massena	ton	38
	NYC	ton	42
	Syracuse	ton	41
	Poughkeepsie	ton	46
Small Office	Albany	ton	202
	Binghamton	ton	195
	Buffalo	ton	195
	Massena	ton	188
	NYC	ton	186
	Syracuse	ton	186
	Poughkeepsie	ton	194
Small Retail	Albany	ton	107
	Binghamton	ton	101
	Buffalo	ton	113
	Massena	ton	95
	NYC	ton	95
	Syracuse	ton	111
	Poughkeepsie	ton	101
Religious	Albany	ton	9
	Binghamton	ton	10
	Buffalo	ton	7
	Massena	ton	6
	NYC	ton	6
	Syracuse	ton	6
	Poughkeepsie	ton	7

Building Type	City	unit	KWh/unit
Warehouse	Albany	ton	3
	Binghamton	ton	5
	Buffalo	ton	2
	Massena	ton	4
	NYC	ton	2
	Syracuse	ton	7
	Poughkeepsie	ton	4
Other	Albany	ton	71
	Binghamton	ton	66
	Buffalo	ton	71
	Massena	ton	61
	NYC	ton	61
	Syracuse	ton	70
	Poughkeepsie	ton	66

Close Approach Cooling Towers

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

High School

City	System type	kWh/ton	kW/ton
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

City	System type	kWh/ton	kW/ton
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

Large Office

City	System type	kWh/ton	kW/ton
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

Hospital

City	System type	kWh/ton	kW/ton
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

Large Retail

City	System type	kWh/ton	kW/ton
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

City	System type	kWh/ton	kW/ton
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

Other

City	System type	kWh/ton	kW/ton
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

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

	Measure Unit Savings (kWh/hp)					
Climate	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

	Measure Unit Savings (kWh/hp)					
Climate	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[38]. These values were trued up to National Grid evaluation studies by computing the ratio of the savings by VFD application from the National Grid Massachusetts Energy Initiative program evaluation to the average value by application across the NSTAR data. This adjustment factor was then applied to each of the NSTAR values. The adjusted savings are shown shown below.

Building	Measure Unit Savings (kWh/hp)								
	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

[38] 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

Peak demand savings were taken from the NSTAR data, as shown below:

Building	Measure Unit Demand Savings (kW/hp)								
	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

APPENDIX L. EISA MINIMUM MOTOR EFFICIENCY

The 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