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

Single Family Residential Measures

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Table of Contents

INTRODUCTION **1**

LIFE-CYCLE SAVINGS **1**

NET TO GROSS ADJUSTMENTS **4**

RESIDENTIAL MEASURES **5**

CFL 5
CFL LIGHT FIXTURE 9
REFRIGERATORS AND FREEZERS – NORMAL REPLACEMENT 13
REFRIGERATORS AND FREEZERS – EARLY REPLACEMENT 16
REFRIGERATOR AND FREEZER RECYCLING 20
CLOTHES WASHER 23
OPAQUE SHELL INSULATION 24
HIGH PERFORMANCE WINDOWS 29
AIR LEAKAGE SEALING 33
CENTRAL AIR CONDITIONING 36
CENTRAL AIR SOURCE HEAT PUMPS 41
BOILERS 44
BOILER RESET CONTROLS 46
SETBACK THERMOSTAT 48
REFRIGERANT CHARGE CORRECTION 51
HIGH EFFICIENCY GAS FURNACES 54
DUCT INSULATION AND LEAKAGE SEALING 57
ROOM AIR CONDITIONER 62
WATER HEATING 65
HEAT PUMP WATER HEATER 69
LOW FLOW SHOWERHEADS 72
FAUCET AERATORS 74
HOT WATER TANK WRAPS 76
ENERGY STAR DEHUMIDIFIER 79
CUSTOM MEASURES 80

APPENDIX A. PROTOTYPICAL BUILDING DESCRIPTIONS **82**

SINGLE FAMILY RESIDENTIAL 82

INTRODUCTION

This document presents the measure-specific energy and demand savings estimation approach to be used by organizations delivering energy efficiency programs to the citizens of New York under the Energy Efficiency Portfolio Standard (EEPS). This edition of the manual covers measures installed in single family residential buildings.

The Commission is committed to using the best possible information in the preparation of this Manual. Information contained within this manual may supersede information contained in earlier versions. In cases where the same measure appears in more than one manual approved by the Commission in 2008-09, and the estimation approach has been updated (e.g. residential CFL, refrigerators), program administrators are reminded to use the most recently approved version of the Manual when reporting energy savings for these measures.

Significant changes to this version of the manual include:

1. Revision to the CFL to incandescent lamp wattage equivalency ratio
2. Reconciliation of discrepancies in water inlet temperatures across water heating and water conservation measures
3. Added dehumidifier measure
4. Added section on custom measure calculations
5. Added HVAC interactive effects multipliers for refrigerators
6. Revisions to energy savings assumption for programmable thermostats
7. Revision to the refrigerator and freezer savings approach, including refrigerator and freezer early replacement and recycling.
8. Revisions to clothes washer savings calculations
9. Revisions to assumptions and savings for opaque shell insulation and window measures
10. Revisions to hot water per capita consumption data
11. Simplification of tank wrap savings calculations
12. Simplification of heat pump water heater calculations
13. Revisions to EER assumptions for air conditioners and heat pumps to comply with program minimum specifications.
14. Additions to the effective useful life (EUL) table.

LIFE-CYCLE SAVINGS

The energy savings methodologies presented in this manual are designed to provide first year annual gross energy savings. To calculate life-cycle savings, the annual first year energy savings must be multiplied by the measure life. For program savings purposes, we believe that measure life should represent not only the engineering/rated life of the product but also the degree to which the product might be removed before its rated life. We thus propose that the term “measure life” be consistent with that used in the *Measure*

Life Report prepared by GDS Associates for the New England State Program Working Group (SPWG):[1]

"For programs delivered by program administrators in New England, Measure Life includes equipment life and measure persistence (not savings persistence).

- Equipment Life means the [mean] number of years that a measure is installed and will operate until failure, and
- Measure Persistence takes into account business turnover, early retirement of installed equipment, and other reasons measures might be removed or discontinued."

This approach is consistent with the approach taken by the California Database for Energy Efficiency Resources (DEER). The DEER study includes recommendations on effective useful life (EUL). The EUL is an estimate of the moment when 50% of the measures are expected to be removed or no longer be functional, which includes the effects of measure persistence and technical degradation. The measure life assumptions to be used in this manual are shown in the table below.

Table 1. Measure Life Estimates

Measure	Effective Useful Life	Source
Aerators	10	DEER
Boiler	25	Efficiency VT[2]
Boiler reset control	15	ACEEE[3]
CENTRAL AIR CONDITIONING	15	DEER
CENTRAL HEAT PUMPS	15	DEER
CFL LIGHT BULB	Coupon - 5 Direct Install - 7 Markdown - 7	New England SPWG[1]
CFL LIGHT FIXTURE	7	Residential Lighting Measure Life Study[4]
Clothes washers	11	DEER
Duct insulation and leakage sealing	18	DEER
ELECTRIC HEAT PUMP WATER HEATER[5]	10	DEER[6]
Furnace	20	DEER
Geothermal Heat Pump	20	DPS
Instantaneous water heaters	20	ACEEE
Programmable setback thermostat	11	DEER
REFRIGERANT CHARGE CORRECTION	10	DEER

[1] GDS Associates, Inc. (2007) *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group for use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM).
[2] Efficiency Vermont Technical Reference Manual, ver. 4.
[3] Potential for Energy Efficiency, Demand Response and Onsite Solar Energy in Pennsylvania, ACEEE report number E093. April 2009.
[4] Residential Lighting Measure Life Study, prepared for the New England Residential Lighting Program Sponsors by Nexus Market Research Inc. and RLW Analytics Inc., June 4, 2008.
[5] Electric heat pump used for service hot water heating.
[6] Effective Useful Life tables to be used by California IOUs for 2009-2011 program cycle planning. From the California DEER website: www.deeresources.com

Measure	Effective Useful Life	Source
Refrigerator	20	CT Manual[7]
Room air conditioners	10	DPS
Showerheads	10	DEER
Tank wrap	10	NYSERDA[8]

In general, gross savings are defined as the difference in energy and demand between a defined baseline measure or system and the efficient measure or system installed through the program. The appropriate baseline can vary depending on whether the situation involves existing buildings, new construction, a replacement on failure situation (normal replacement), or an early replacement situation. Below are the various definitions of baseline for these four situations:

1. If new construction, the baseline is the typical measure or system that would have been installed without the program. For new construction, building efficiency codes generally define the baseline.

2. If a replace on failure situation (normal replacement) and there is no applicable efficiency code, the baseline is the typical measure or system that would have been installed without the program.

3. If a replace on failure situation (normal replacement) and there is an applicable efficiency code, the baseline is the typical measure or system whose rated energy use is consistent with that code.

4. For early replacement of older but functioning equipment, the measure savings are generally calculated in a two step process. This is called the "dual baseline" approach.

   a) Calculate savings using the existing equipment efficiency as the baseline over the remaining life of the existing equipment.
   b) After the existing equipment has reached the end of its remaining useful life, calculate savings using normal replacement efficiency as the baseline over the remaining effective useful life of the new equipment.

To avoid complications associated with conducting separate calculations for each baseline, program administrators are offered two options for reporting savings on early replacement measures:

Option 1. Treat the measure as a normal replacement, using the appropriate baseline as described above. The measure life is equal to the effective useful life listed in the table above, and the measure cost is calculated as the incremental cost of the measure relative to the normal replacement baseline equipment.

[7] CL&P and UI Program Savings Documentation for 2008 Program Year
[8] NYSERDA Energy Smart Program Deemed Savings Database. Rev 9 – 062006.

Option 2. Treat the measure as an early replacement, using the existing equipment as the baseline. The measure life is equal to the remaining useful life, which is defined as 1/3 of the effective useful life listed in the table above. Savings beyond the remaining useful life would be set to zero. The measure cost is calculated as the full cost of the measure.

NET TO GROSS ADJUSTMENTS

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

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

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

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.

Savings Estimation Approach

Annual Energy Savings = Δ Watts x Hours x Days-per-Year/1000

Variables and Assumptions
1) 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.

2) Hours of bulb use per day

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.[9] 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.[10] 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 NYS 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.

3) 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.

The following chart can be used to derive annual savings for various size bulbs. This uses the assumed values above to provide the annual kWh savings. Note that actual bulb wattage should be used to calculate energy savings – using a default average could lead to a large margin of error.

CFL Bulb Wattage	Annual kWh Savings	**CFL Bulb Wattage**	Annual kWh Savings
7	20.7	**19**	56.1
8	23.6	**20**	59.1
9	26.6	**21**	62.1
10	29.6	**22**	65.0
11	32.5	**23**	68.0
12	35.2	**24**	70.9
13	38.4	**25**	73.9
14	41.4	**26**	76.8
15	44.3	**27**	79.8
16	47.3	**28**	82.7
17	50.2	**29**	85.7
18	53.2	**30**	88.7

Demand Savings
The demand savings here represent the level of reduction in demand at the time of system peak. They are typically calculated for a portfolio of installed or planned installations of

[9] "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1.
[10] 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 products rather than a single lamp. The calculation, however, is the same. Demand savings are calculated by multiplying the kW difference between the wattage or total load of the energy efficient product(s) and that of the baseline product(s), or delta watts, by the coincidence factor which reflects the amount of that demand which is in use at the time of system peak. The coincidence factors presented below are used to adjust the maximum delta watts into a demand value that is coincident to the specified peak summer and winter periods.[11]

Demand savings = delta watts x coincidence factor

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

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

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

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

[11] 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, p. III.

"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.

CFL LIGHT FIXTURE

Measure Description

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.
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Savings Estimation Approach

Annual Energy Savings = Δ Watts x Hours x Days-per-Year/1000

Variables and Assumptions
1) 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 light fixtures are purchased from many product sources (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 fixture (what is being replaced or what would have been used instead of the CFL fixture). The alternative approach is to use a method that avoids the determination of the baseline for each recorded CFL fixture by assuming that that the CFL fixture 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. For dimmable or three-way CFL fixture, 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.

2) Hours of bulb use per day

Hours = 2.5 Hours per day

The 2.5 hours of use per day is a value derived from an extended (nine month – May through February) logger study conducted during 2003 in Massachusetts, Rhode Island, and Vermont.[12] 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

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

lighting program for Efficiency Maine reports daily hours of use at 2.4 for interior fixtures.[13] The proposed 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 NYS 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.

3) 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.

The following chart can be used to derive annual savings for various size bulbs. This uses the assumed values above to provide the annual kWh savings. Note that actual bulb wattage should be used to calculate energy savings – using a default average could lead to a large margin of error.

CFL Bulb Wattage	Annual kWh Savings	**CFL Bulb Wattage**	Annual kWh Savings
7	16.2	**19**	43.9
8	18.5	**20**	46.2
9	20.8	**21**	48.5
10	23.1	**22**	50.8
11	25.4	**23**	53.1
12	27.7	**24**	55.4
13	30.0	**25**	57.7
14	32.3	**26**	60.0
15	34.6	**27**	62.3
16	36.9	**28**	64.6
17	39.2	**29**	67.0
18	41.6	**30**	69.3

Demand Savings

The demand savings here represent the level of reduction in demand at the time of system peak. They are typically calculated for a portfolio of installed or planned installations of lighting products rather than a single lamp. The calculation, however, is the same. Demand savings are calculated by multiplying the kW difference between the wattage or total load of the energy efficient product(s) and that of the baseline product(s), or delta

[13] 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.

watts, by the coincidence factor which reflects the amount of that demand which is in use at the time of system peak. The coincidence factors presented below are used to adjust the maximum delta watts into a demand value that is coincident to the specified peak summer and winter periods.[14]

Demand savings = delta watts x coincidence factor

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

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

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

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

[14] 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, p. III.

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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

ACES: Default Deemed Savings Review Final Report for State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation, prepared by Ron Swager and Chris Burger, Patrick Engineering for PA Government Services Inc., June 24, 2008

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.

REFRIGERATORS AND FREEZERS – NORMAL REPLACEMENT

Description of Measure

This section covers end-of-life (normal) replacement of refrigerators or freezers with Energy Star refrigerators or freezers in single-family residential homes. High-efficiency refrigerators and freezers save energy and demand through improved compressor design, better case wall insulation, improved door seals, and improvements to defrost and anti-sweat heater controls. The calculations in this section assume that the replaced refrigerator is no longer functioning and will not be returned to the grid.

Annual Energy and Summer Peak Demand Savings

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

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

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

where:

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

Normal Replacement Baseline Refrigerator or Freezer Energy Consumption (kWh_{base}). Energy consumption for the normal replacement baseline refrigerator or freezer 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[15] according to the make and model of the purchased refrigerator.

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

Efficient Refrigerator or Freezer Energy Consumption (kWh_{ee}). Energy consumption for the new refrigerator or freezer 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 purchased refrigerator.

Operating Hours

The equations above assume the refrigerator/freezer is operating year round. The cycling of the compressor is considered in the annual energy consumption estimates.

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 the tables below:

AC with gas heat

	$HVAC_c$	$HVAC_d$	$HVAC_g$
Albany	0.043	0.073	-0.026
Binghamton	0.034	0.182	-0.014
Buffalo	0.040	0.171	-0.027
Massena	0.034	0.112	-0.029
NYC	0.077	0.085	-0.023
Syracuse	0.045	0.095	-0.019

Heat Pump

	$HVAC_c$	$HVAC_d$	$HVAC_g$
Albany	-0.214	0.119	0.000
Binghamton	-0.148	0.169	0.000
Buffalo	-0.230	0.190	0.000
Massena	-0.298	0.131	0.000
NYC	-0.105	0.111	0.000
Syracuse	-0.157	0.119	0.000

AC with electric heat

	$HVAC_c$	$HVAC_d$	$HVAC_g$
Albany	-0.575	0.073	0.000
Binghamton	-0.603	0.182	0.000
Buffalo	-0.655	0.171	0.000
Massena	-0.489	0.112	0.000
NYC	-0.579	0.085	0.000
Syracuse	-0.615	0.095	0.000

Electric heat only

	$HVAC_c$	$HVAC_d$	$HVAC_g$
Albany	-0.521	0.000	0.000
Binghamton	-0.313	0.000	0.000
Buffalo	-0.551	0.000	0.000
Massena	-0.607	0.000	0.000
NYC	-0.403	0.000	0.000
Syracuse	-0.382	0.000	0.000

Gas heat only

	$HVAC_c$	$HVAC_d$	$HVAC_g$
Albany	0.000	0.000	-0.026
Binghamton	0.000	0.000	-0.014
Buffalo	0.000	0.000	-0.027
Massena	0.000	0.000	-0.029
NYC	0.000	0.000	-0.023
Syracuse	0.000	0.000	-0.019

Notes & References

1. The Energy Star website has a directory of Energy Star qualified refrigerators and freezers by make and model number. The directory also lists the baseline energy consumption according to NAECA standards for the size and type of refrigerator or freezer purchased. See www.energystar.gov.

Revision Number

0

REFRIGERATORS AND FREEZERS – EARLY REPLACEMENT

Description of Measure

This section covers early replacement of operating refrigerators or freezers with Energy Star refrigerators or freezers in single-family residential homes. High-efficiency refrigerators and freezers save energy and demand through improved compressor design, better case wall insulation, improved door seals, and improvements to defrost and anti-sweat heater controls. The calculations in this section assume that the replaced refrigerator is removed from the grid through disposal or recycling.

Annual Energy and Summer Peak Demand Savings

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

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

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

where:

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

Early Retirement Baseline Refrigerator or Freezer Energy Consumption

Early retirement baseline refrigerator or freezer annual consumption will be estimated from manufacturers' nameplate data from the replaced unit. Nameplate information such as manufacturer, model number, year manufactured, and volume will be used to lookup the DOE rated kWh per year. The data used in the lookup table shall be reviewed and approved by the Commission. DOE rated energy consumption shall be adjusted for unit age, number of occupants in the dwelling unit, and door seal condition using the following equation:

$kWh_{base} = kWh_{DOE,base} \times F_{age} \times F_{occ} \times F_{seal}$

where:

F_{age} = age degradation factor
F_{occ} = occupant degradation factor
F_{seal} = seal degradation factor
kWh_{DOE} = estimated annual kWh/yr according to DOE rating

The values used for the degradation factors are shown below[16]:

Age of Unit	F_{age}
0 – 4 years old	1.00
5 – 9 years old	1.05
10 – 14 years old	1.10
15 or greater	1.15

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

Seal or Gasket Condition	F_{seal}
Good	1.00
Some Deterioration	1.05
Gaps Visible	1.15

Seal or Gasket Inspection Guidance for Assessing Condition

Conduct a visual inspection of the unit and score the condition of the seal using the following guidance.

A. Good Condition: the seal is sealing properly and performing as would be expected from a new unit; shows no sign of twisting, cracking, separation, perforation, fraying, and is essentially providing a barrier prohibiting exchange of air into or out of the unit.

[16] Values taken from National Energy Audit Tool (NEAT). Oak Ridge National Laboratory, Oak Ridge, TN. http://weatherization.ornl.gov/national_energy_audit.htm

B. Some Deterioration: there is some signs of small areas of seal twisting, cracking, separation, perforation, or fraying, such that the seal is capable of confecting small amounts of air through less than 25% of the seal area while the door is closed.
C. Gaps Visible: the seal shows substantial signs of twisting, cracking, separation, perforation, or fraying, such that the seal is capable of leaking air over more than 25% of the seal area.

For programs where it is prohibitively expensive to inspect participating units, inspect a representative sample of the units covered by the program and apply the mean adjustments at the population level.

Efficient Refrigerator or Freezer Energy Consumption

Energy consumption for the new refrigerator or freezer shall be determined from the DOE rating for the make and model number of the replacement unit, adjusted for the number of occupants, as shown in the equation below:

$$kWh_{ee} = kWh_{DOE,ee} \times F_{occ}$$

where:

$kWh_{DOE,ee}$ = DOE rated energy consumption for new 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 purchased refrigerator.

Operating Hours

The equations above assume the refrigerator/freezer is operating year round. The cycling of the compressor is considered in the annual energy consumption estimates.

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. See Refrigerator and Freezer Normal Replacement section above for the appropriate interactive effects factors.

Additional Grid Based Savings Caused by the Program

Beyond the savings provided by the units replaced and recycled, there are market based impacts associated with these programs. Programs that promote early replacement of operating units and which require the old units to be dismantled and recycled save

addition amounts of energy by limiting the number of older inefficient units moved into the secondary market or used as secondary units in the homes of the participants. While these levels of savings are uncertain, some evaluation has been done to help estimate the degree of impact associated with these market effects.

Current literature[17] suggests an additional savings of 15% to 25% from the secondary market effects of refrigerator recycling. For the purposes of projecting ex ante savings, early replacement units caused by the programs should increase their estimated gross savings (using the approach specified in this technical manual) by 20% for each units recycled because of the savings that are provided to the grid as a result of secondary market effects.

Gross savings x .20 = grid adjusted savings
Gross demand x .20 = grid adjusted demand savings

Ex ante savings associated with these programs should be addressed in the program-specific independent evaluation efforts in order to improve the accuracy of the secondary market effects estimated in this technical manual. As these studies are conducted these adjustments shall be updated based on New York specific studies. The adjustments are included in the technical manual to recognize their contributions to savings and to identify the need for additional New York specific evaluation research needed to improve the impact estimates.

Notes & References

1. The National Energy Audit Tool (NEAT) has a directory of annual refrigerator energy consumption by age, make and model number. See http://weatherization.ornl.gov/national_energy_audit.htm

2. The Energy Star website has a directory of Energy Star qualified refrigerators and freezers by make and model number. The directory also lists the baseline energy consumption according to NAECA standards for the size and type of refrigerator or freezer purchased. See www.energystar.gov.

Revision Number

0

[17] April 2008, Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Programs, ADM Associates, and; February 2004, Measurement and Evaluation Study of the 2002 Statewide Residential Appliance Recycling Program, KEMA,

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[18] or secondary refrigerator. .

Annual Energy and Summer Peak Demand Savings

$$\Delta kWh = units \times (kWh_{base}) \times (1 + HVAC_c)$$

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

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

where:

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

Baseline Refrigerator or Freezer Energy Consumption

Early retirement baseline refrigerator or freezer annual consumption will be estimated from manufacturers' nameplate data from the replaced unit. Nameplate information such as manufacturer, model number, year manufactured, and volume will be used to lookup the DOE rated kWh per year. The data used in the lookup table shall be reviewed and approved by the Commission. DOE rated energy consumption shall be adjusted for unit age and door seal condition using the following equation:

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

$kWh_{base} = kWh_{DOE,base} \times F_{age} \times F_{seal}$

where:

F_{age} = age degradation factor
F_{seal} = seal degradation factor
kWh_{DOE} = estimated annual kWh/yr according to DOE rating

Note, since many recycled refrigerators or freezers are "second" units, the occupancy degradation factors will not apply. The values used for the degradation factors are shown below[19]:

Age of Unit	F_{age}
0 – 4 years old	1.00
5 – 9 years old	1.05
10 – 14 years old	1.10
15 or greater	1.15

Seal or Gasket Condition	F_{seal}
Good	1.00
Some Deterioration	1.05
Gaps Visible	1.15

See section on early replacement above for more information on seal or gasket condition assessment.

Operating Hours

The equations above assume the refrigerator/freezer is operating year round. The cycling of the compressor is considered in the annual energy consumption estimates.

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. See Refrigerator and Freezer Normal Replacement section above for the appropriate interactive effects factors.

Additional Grid Based Savings Caused by the Program

[19] Values taken from National Energy Audit Tool (NEAT). Oak Ridge National Laboratory, Oak Ridge, TN. http://weatherization.ornl.gov/national_energy_audit.htm

Beyond the savings provided by the recycled units, there are market based impacts associated with these programs. Recycling programs that pick units up and dismantle them, impact the secondary market by limiting the number of old units entering that market. While these levels of savings are uncertain, some evaluation has been done to help estimate the degree of impact associated with these market effects.

Current literature[20] suggests an additional savings of 10% to 15% from the secondary market effects of refrigerator recycling. For the purposes of projecting ex ante savings, from the picked up and recycled units gross savings (using the approach specified in this technical manual) can be increased by 12.5% because of the savings that are provided to the grid as a result of secondary market effects.

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Gross savings x .125 = grid adjusted savings
Gross demand x .125 = grid adjusted demand savings

Ex ante savings associated with these programs should be addressed in the program-specific independent evaluation efforts in order to improve the accuracy of the secondary market effects estimated in this technical manual. As these studies are conducted these adjustments shall be updated based on New York specific studies. The adjustments are included in the technical manual to recognize their contributions to savings and to identify the need for additional New York specific evaluation research needed to improve the impact estimates.

Notes & References

1. The National Energy Audit Tool (NEAT) has a directory of annual refrigerator energy consumption by age, make and model number. See http://weatherization.ornl.gov/national_energy_audit.htm

Revision Number

0

[20] April 2008, Evaluation Study of the 2004-2005 Statewide Residential Appliance Recycling Programs, ADM Associates, and; February 2004, Measurement and Evaluation Study of the 2002 Statewide Residential Appliance Recycling Program, KEMA,

CLOTHES WASHER

Measure Description

Residential clothes washers meeting the minimum qualifying efficiency standards establishes under the Energy Star Program.

Savings Estimation Approach

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[21]. The number of wash cycles per year is assumed to be 392.

Annual Energy and Resource Savings

	Efficiency	Clothes Washer		Hot Water Heater		Dryer	
		Electric	Water	Natural Gas	Electric	Natural Gas	Electric
	MEF[22]	(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

Demand Savings

Apply coincidence factors to the energy savings:
Coincidence factors for electric use:
kW = CF * kWh savings / 8760

Based on data from the Efficiency Vermont TRM[23], CF = .06

[21] See http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls

[22] 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.

[23] Technical Reference User Manual (TRM) No. 4-19, Efficiency Vermont, 9/5/2003

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, and so on. Energy and demand saving are realized through reductions in the building heating and cooling loads.

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings
$\Delta kW_S = SF \times (\Delta kW/SF) \times DF_S \times CF_S$

Gross Annual Energy Savings
$\Delta kWh = SF \times (\Delta kWh/SF)$

$\Delta therm = SF \times (\Delta therm/SF)$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
SF	= insulation square feet installed
DF	= demand diversity factor
CF	= coincidence factor
ΔkW/SF	= electricity demand savings per square foot of insulation installed
ΔkWh/SF	`= electricity consumption savings per square foot of insulation installed
Δtherm/SF	= gas consumption savings per square foot of insulation installed

Unit energy and demand savings calculated from the building prototype simulation models are shown below. The savings are tabulated by building type, vintage and HVAC system type.

AC/gas furnace

City	Vintage	Wall Insulation		Ceiling Insulation	
		kWh/ 1000SF	kW/ 1000SF	kWh/ 1000SF	kW/ 1000SF
Albany	Old	59	0.043	75	0.068
	Average	11	0.000	36	0.017
Binghamton	Old	54	0.065	69	0.102
	Average	8	0.000	32	0.017
Buffalo	Old	55	0.043	66	0.068
	Average	5	0.000	26	0.034

City	Vintage	Wall Insulation		Ceiling Insulation	
		kWh/ 1000SF	kW/ 1000SF	kWh/ 1000SF	kW/ 1000SF
Massena	Old	65	0.054	78	0.068
	Average	8	0.011	38	0.034
NYC	Old	69	0.076	91	0.119
	Average	8	0.000	46	0.017
Syracuse	Old	64	0.033	74	0.051
	Average	7	0.000	35	0.034

Heat pump

City	Vintage	Wall Insulation		Ceiling Insulation	
		kWh/ 1000SF	kW/ 1000SF	kWh/ 1000SF	kW/ 1000SF
Albany	Old	1,014	0.043	1,248	0.068
	Average	136	0.011	550	0.034
Binghamton	Old	1,102	0.043	1,346	0.068
	Average	148	0.000	596	0.034
Buffalo	Old	1,088	0.033	1,280	0.051
	Average	140	0.000	570	0.034
Massena	Old	1,342	0.054	1,647	0.068
	Average	182	0.000	730	0.034
NYC	Old	547	0.065	667	0.119
	Average	73	0.011	302	0.051
Syracuse	Old	1,002	0.043	1,210	0.051
	Average	130	0.000	538	0.017

AC with electric furnace

City	Vintage	Wall Insulation		Ceiling Insulation	
		kWh/ 1000SF	kW/ 1000SF	kWh/ 1000SF	kW/ 1000SF
Albany	Old	1,496	0.043	1,787	0.068
	Average	215	0.000	833	0.017
Binghamton	Old	1,561	0.065	1,855	0.102
	Average	220	0.000	860	0.017
Buffalo	Old	1,562	0.043	1,778	0.068
	Average	212	0.000	837	0.034
Massena	Old	1,787	0.054	2,140	0.068
	Average	253	0.011	986	0.034
NYC	Old	1,045	0.076	1,249	0.119
	Average	145	0.000	590	0.017
Syracuse	Old	1,484	0.033	1,737	0.051
	Average	206	0.000	822	0.034

Electric heat no AC

City	Vintage	Wall Insulation		Ceiling Insulation	
		kWh/ 1000SF	kW/ 1000SF	kWh/ 1000SF	kW/ 1000SF
Albany	Old	1,466	0.000	1,746	0.000
	Average	208	0.000	813	0.000
Binghamton	Old	1,539	0.000	1,823	0.000
	Average	217	0.000	845	0.000
Buffalo	Old	1,538	0.000	1,747	0.000
	Average	211	0.000	828	0.000
Massena	Old	1,758	0.000	2,103	0.000
	Average	250	0.000	968	0.000
NYC	Old	996	0.000	1,182	0.000
	Average	140	0.000	555	0.000
Syracuse	Old	1,449	0.000	1,697	0.000
	Average	203	0.000	802	0.000

Gas heat no AC

City	Vintage	Wall Insulation		Ceiling Insulation	
		kWh/ 1000SF	kW/ 1000SF	kWh/ 1000SF	kW/ 1000SF
Albany	Old	30	0.000	35	0.000
	Average	4	0.000	16	0.000
Binghamton	Old	32	0.000	37	0.000
	Average	4	0.000	17	0.000
Buffalo	Old	32	0.000	35	0.000
	Average	4	0.000	17	0.000
Massena	Old	36	0.000	41	0.000
	Average	5	0.000	19	0.000
NYC	Old	20	0.000	24	0.000
	Average	3	0.000	11	0.000
Syracuse	Old	30	0.000	34	0.000
	Average	4	0.000	16	0.000

Unit gas savings by climate and building vintage are shown in the table below:

Gas savings, all gas heating system types

City	Vintage	Wall Ins	Roof Ins
		Therm/ 1000 SF	Therm/ 1000 SF
Albany	Old	64.9	76.8
Albany	Average	9.3	36.2
Binghamton	Old	67.4	79.2
Binghamton	Average	9.6	37.2
Buffalo	Old	67.5	76.1
Buffalo	Average	9.4	36.5

City	Vintage	Wall Ins Therm/ 1000 SF	Roof Ins Therm/ 1000 SF
Massena	Old	76.8	91.1
Massena	Average	11.2	42.5
NYC	Old	45.4	53.4
NYC	Average	6.5	25.4
Syracuse	Old	64.3	74.7
Syracuse	Average	9.2	35.8

The ***demand diversity 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 demand diversity factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the demand diversity factor and coincidence factors are shown below:

Parameter	Recommended Values
Demand diversity factor	0.8
Coincidence factor	1.0

Baseline Efficiencies from which savings are calculated

Baseline wall and ceiling insulation levels by vintage are as follows:

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

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

Compliance Efficiency from which incentives are calculated

Measure wall and ceiling insulation levels by vintage are as follows:

Vintage	Assumed R-value of insulated wall	Notes
Older, poorly insulated	13	2 by 4 wall filled with blown-in insulation
Existing, average insulation	18	R-5 additional insulated sheathing

Vintage	Assumed R-value of insulated ceiling	Notes
Older, poorly insulated	38	Additional blown-in insulation
Existing, average insulation	38	Additional blown-in 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

Notes & References

1. Typical values for demand diversity factor (DF) and coincidence factor (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
0

HIGH PERFORMANCE WINDOWS

Description of Measure

Energy Star windows with reduced thermal conductance solar heat gain coefficient

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings

ΔkW_S = Glazing area (100 SF) $\times$ (ΔkW/100 SF) $\times$ $DF_S \times CF_S$

Gross Annual Energy Savings

ΔkWh = Glazing area (100 SF) $\times$ (ΔkWh/ 100 SF)

Δtherm = Glazing area (100 SF) $\times$ (Δtherm/ 100 SF)

where:

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

Unit energy and demand savings calculated from the building prototype simulation models are shown below. The savings are tabulated by building type, vintage and HVAC system type.

Window Unit Energy and Demand Savings for Single Family Residential Buildings

City	Vintage	AC with gas furnace		Heat pump		AC with electric heat	
		kWh/ 100 SF	kW/ 100SF	kWh/ 100 SF	kW/ 100SF	kWh/ 100 SF	kW/ 100SF
Albany	Old	194	0.220	922	0.199	1,137	0.220
Albany	Average	167	0.171	908	0.178	1,280	0.171
Binghamton	Old	153	0.213	1,015	0.206	1,240	0.213
Binghamton	Average	135	0.156	984	0.156	1,357	0.156
Buffalo	Old	172	0.213	1,031	0.192	1,279	0.213
Buffalo	Average	149	0.142	1,004	0.156	1,412	0.142
Massena	Old	173	0.213	1,161	0.199	1,337	0.213
Massena	Average	152	0.171	1,168	0.149	1,505	0.171
NYC	Old	252	0.235	582	0.249	798	0.235
NYC	Average	219	0.185	588	0.220	955	0.185
Syracuse	Old	194	0.149	959	0.164	1,214	0.149
Syracuse	Average	160	0.142	892	0.142	1,284	0.142

Window Savings (contd.)

City	Vintage	Electric heat no AC		Gas heat no AC	
		kWh/ 100 SF	kW/ 100SF	kWh/ 100 SF	kW/ 100SF
Albany	Old	961	0.000	19	0.000
Albany	Average	1,136	0.000	23	0.000
Binghamton	Old	1,110	0.000	23	0.000
Binghamton	Average	1,248	0.000	26	0.000
Buffalo	Old	1,130	0.000	23	0.000
Buffalo	Average	1,289	0.000	26	0.000
Massena	Old	1,188	0.000	23	0.000
Massena	Average	1,380	0.000	27	0.000
NYC	Old	556	0.000	11	0.000
NYC	Average	750	0.000	15	0.000
Syracuse	Old	1,041	0.000	21	0.000
Syracuse	Average	1,147	0.000	23	0.000

The therm impacts per unit by climate and building vintage are shown below:

Window gas impacts

City	Vintage	Therm/100SF
Albany	Old	41.3
Albany	Average	50.1
Binghamton	Old	47.2
Binghamton	Average	54.6
Buffalo	Old	48.3
Buffalo	Average	56.7
Massena	Old	50.3
Massena	Average	60.3
NYC	Old	24.0

City	Vintage	Therm/100SF
NYC	Average	33.6
Syracuse	Old	44.9
Syracuse	Average	50.9

The ***demand diversity factor*** is used to account for the fact that not all HVAC systems in all buildings treated by window films were installed are operating at the same time. The demand diversity factor is defined as the average fraction of installed capacity of the HVAC systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the demand diversity factor and coincidence factors are shown below:

Parameter	Recommended Values
Demand diversity factor	0.8
Coincidence factor	1.0

Baseline Efficiencies from which savings are calculated

The baseline condition for the old vintage building is assumed to be single pane clear glass with a solar heat gain coefficient of 0.87 and U-value of 0.93 Btu/hr-SF-deg F. The baseline condition for the average vintage building is assumed to be double pane clear glass with a solar heat gain coefficient of 0.77 and U-value of 0.87 Btu/hr-SF-deg F.

Compliance Efficiency from which incentives are calculated

The Energy Star window is assumed to provide a solar heat gain coefficient of 0.40 and a glass conductance of 0.32 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

Notes & References

1. Window properties taken from ASHRAE Handbook of Fundamentals
2. Typical values for demand diversity factor (DF) and coincidence factor (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

0

AIR LEAKAGE SEALING

Description of Measure

Reduction in the natural infiltration rate of the home through sealing air leaks in the building envelope.

Method for Calculating Summer Peak Demand and Energy Savings

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

Gross Annual Energy Savings
ΔkWh = Floor area (1000 SF) $\times$ (ΔkWh/ 1000 SF)

Δtherm = Floor area (1000 SF) $\times$ (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 below. The savings are tabulated by building type, vintage, and HVAC system type.

Air Leakage Sealing Energy and Demand Impacts

City	Vintage	AC with gas furnace		Heat pump		AC with electric heat	
		kWh/ 1000 SF	kW/ 1000SF	kWh/ 1000 SF	kW/ 1000SF	kWh/ 1000 SF	kW/ 1000SF
Albany	Old	40	0.114	992	0.034	1,434	0.114
Albany	Average	23	0.011	482	0.023	744	0.011
Binghamton	Old	38	0.125	1,096	0.091	1,528	0.125
Binghamton	Average	19	0.000	535	0.034	785	0.000
Buffalo	Old	50	0.137	1,325	0.125	1,856	0.137
Buffalo	Average	24	0.023	624	0.046	935	0.023
Massena	Old	39	0.034	1,214	0.046	1,622	0.034
Massena	Average	27	0.023	620	0.034	865	0.023
NYC	Old	80	0.159	793	0.102	1,470	0.159
NYC	Average	39	0.046	369	0.046	713	0.046
Syracuse	Old	43	0.080	1,004	0.068	1,425	0.080
Syracuse	Average	22	0.046	462	0.034	704	0.046

Air Leakage Sealing Energy and Demand Impacts (contd.)

City	Vintage	Electric heat no AC		Gas heat no AC	
		kWh/ 1000 SF	kW/ 1000SF	kWh/ 1000 SF	kW/ 1000SF
Albany	Old	1,423	0.000	29	0.000
Albany	Average	736	0.000	15	0.000
Binghamton	Old	1,522	0.000	32	0.000
Binghamton	Average	783	0.000	17	0.000
Buffalo	Old	1,845	0.000	39	0.000
Buffalo	Average	930	0.000	19	0.000
Massena	Old	1,615	0.000	33	0.000
Massena	Average	857	0.000	18	0.000
NYC	Old	1,421	0.000	30	0.000
NYC	Average	688	0.000	14	0.000
Syracuse	Old	1,412	0.000	30	0.000
Syracuse	Average	696	0.000	14	0.000

The air leakage sealing therm impacts per unit are shown below:

Air Leakage Sealing Unit Therm Impacts

City	Vintage	Therm/ 1000SF
Albany	Old	63
Albany	Average	33
Binghamton	Old	66
Binghamton	Average	35
Buffalo	Old	80
Buffalo	Average	41

City	Vintage	Therm/ 1000SF
Massena	Old	70
Massena	Average	38
NYC	Old	64
NYC	Average	32
Syracuse	Old	62
Syracuse	Average	31

Baseline Efficiencies from which savings are calculated

Baseline infiltration rate is assumed be as follows:

Vintage	Infiltration rate (natural ACH)
Old	1.0
Average	0.5

Compliance Efficiency from which incentives are calculated

Savings are based on an infiltration rate reduction of 30%

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

Notes & References

1. Typical values for demand diversity factor (DF) and coincidence factor (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

0

CENTRAL AIR CONDITIONING

Description of Measure

Central air conditioning systems with rated efficiency of 14 SEER or higher in single 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

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

$$\Delta kWh = units \times \frac{tons}{unit} \times RLF \times \left(\frac{12}{\overline{EER}_{base} \times \eta_{duct}} - \frac{12}{\overline{EER}_{ee} \times \eta_{duct}} \right) \times CLH$$

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
$\overline{EER}$	= average energy efficiency ratio over the cooling season[24]. (Btu/watt- hour)
EER_{pk}	= energy efficiency ratio under peak conditions (Btu/watt-hour)
CLH	= cooling load hours
RLF	= rated load factor
DF	= demand diversity factor
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

The ***rated load factor*** is the ratio of the peak cooling load imposed on the cooling equipment to the total rated cooling capacity. This factor compensates for oversizing of the air conditioning unit.

$$RLF = \frac{peak\ cooling\ load}{nameplate\ capacity}$$

[24] The average seasonal efficiency is analogous to the SEER used by equipment manufacturers to rate the seasonal performance of air conditioners in an average US climate, according ARHI Standard 210/240. See discussion in text.

The ***average seasonal cooling efficiency*** ($\overline{EER}$) 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.
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Cooling load hours are defined as the ratio of the building annual cooling load to the building peak cooling load:

$$CLH = \frac{\text{Annual Cooling Load (Btu)}}{\text{Peak Cooling Load (Btu / hr)}}$$

Cooling **equivalent full-load hours** (EFLH) are sometimes used to estimate total energy savings. EFLH are defined as follows:

$$EFLH = \frac{\text{Annual kWh}_{\text{cooling}}}{\text{kW}_{\text{peak, cooling}}}$$

Since EFLH are calculated from the total kWh and peak kW of the air conditioner, the efficiency characteristics of the air conditioner affect the EFLH. To eliminate the dependence on HVAC system performance characteristics, the EFLH can be converted to CLH using the following equation:

$$CLH = EFLH \times \frac{\overline{EER}}{EER_{pk}}$$

where:

$EFLH$ = equivalent full-load hours
$\overline{EER}$ = average air conditioning equipment energy efficiency ratio
EER_{pk} = air conditioning equipment energy efficiency ratio under peak conditions

The ***demand diversity 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 demand diversity factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the rated load factor, demand diversity factor and coincidence factors are shown below:

Parameter	Recommended Values
Rated Load Factor	0.8
Demand diversity factor	0.8
Coincidence factor	1.0

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)[25]
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[26]
		SEER 15	12.72
		SEER 16	13.0[27]
		SEER 17	13.0[28]
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[29]
		SEER 15	12.5[30]
		SEER 16	12.5[31]
		SEER 17	12.52
		SEER 18	12.8

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

Cooling load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical residential buildings. The prototype building characteristics are described

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

in Appendix A. Residential prototypes for three different classes of building vintage were developed:

1. Old, poorly insulated building constructed in the 1950s or earlier. This vintage is referred to as the "old" vintage
2. Existing, average insulated building conforming to 1980s era building codes. This vintage is referred to as the "average" vintage.
3. New construction conforming to current NY state standards for residential new construction. This vintage is referred to as the "new" vintage.

The CLH for three building vintages and six different cities in NY are shown below:

Single Family Detached Cooling Load Hours by Vintage and City

City	Old	Average	New
Albany	403	387	349
Binghamton	249	246	198
Buffalo	417	402	345
Massena	322	312	263
NYC	837	788	811
Syracuse	387	370	335

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.

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 demand diversity factor (DF), coincidence factor (CF) and rated load factor (RLF) taken from Engineering Methods for Estimating the Impacts of Demand-Side Management Programs. Volume 2: Fundamental Equations for Residential and Commercial End-Uses. TR-100984S Vol 2. Electric Power Research Institute, Palo Alto, CA August, 1993.

3. 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
0

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

$$\Delta kWh = units \times \frac{kBtuh}{unit} \times RLF_{heat} \times \left(\frac{1}{\overline{COP}_{base}} - \frac{1}{\overline{COP}_{ee}} \right) \times \frac{HLH}{3.413}$$

where:

ΔkWh	= gross annual energy savings
units	= number of heat pumps installed
kBtuh/unit	= the nominal rating of the heating capacity of the heat pumps in kBtu/hr
$\overline{COP}$	= average heating season coefficient of performance of heat pump
HLH	= heating load hours
RLF_{heat}	= heating mode rated load factor
3.413	= conversion factor (Btu/Wh)

The ***rated load factor*** is the ratio of the peak heating load imposed on the heating equipment to the total rated heating capacity, including the supplemental heating (strip heat). This factor compensates for oversizing of the heat pump.

$$RLF = \frac{peak\ heating\ load}{nameplate\ \text{heating}\ capacity}$$

Recommended value for the rated load factor is 0.8.

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)[32]
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[33]
	SEER 15	8.8
	SEER 16	8.5[34]
	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 remaining life. According to the 2004-5 DEER update study, equipment of this vintage is generally SEER 10.

Heating load hours are defined as the ratio of the annual building heating load to the peak building heating load:

$$\text{HLH} = \frac{\text{Annual Heating Load (Btu)}}{\textit{Peak}\ \text{Heating Load (Btu/hr)}}$$

Heating 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 HLH for three building vintages and six different cities in NY are shown below:

Single Family Detached Heating Load Hours by Vintage and City

City	Old	Average	New
Albany	1,836	1,724	1,630
Binghamton	1,914	1,813	1,696
Buffalo	1,912	1,841	1,708
Massena	1,982	1,870	1,778
NYC	1,288	1,168	1,076
Syracuse	1,832	1,739	1,622

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

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).

Compliance Efficiency from which incentives are calculated

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

Operating Hours

Heating load hours vary by climate and building vintage. See table above.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated – electric heating system

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
0

BOILERS

Description of Measure

High efficiency condensing and non-condensing hot water and steam boilers

Method for Calculating Energy Savings

$$\Delta\text{therms} = \text{units} \times \frac{\text{kBtuh}}{\text{unit}} \times \text{RLF}_{\text{heat}} \times \left(\frac{1}{\bar{\eta}_{base} \times \bar{\eta}_{dist,base}} - \frac{1}{\bar{\eta}_{ee} \times \bar{\eta}_{dist,ee}} \right) \times \frac{\text{HLH}}{100}$$

where:

Δtherms	= gross annual gas savings
units	= number of boilers installed
kBtuh/unit	= the nominal rating of the heating capacity of the boiler in kBtu/hr
$\bar{\eta}$	= average heating season efficiency of boiler
$\bar{\eta}_{\text{dist}}$	= average heating season distribution system efficiency
HLH	= heating load hours
RLF_{heat}	= heating mode rated load factor
100	= conversion factor (kBtuh/therm)

The ***rated load factor*** is the ratio of the peak heating load imposed on the heating equipment to the total rated heating capacity. This factor compensates for oversizing of the boiler.

$$\text{RLF}_{\text{heat}} = \frac{peak\ \ heating\ \ load}{nameplate\ \ \text{heating}\ \ capacity}$$

Recommended value for the rated load factor is 0.8.

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 load hours are defined as the ratio of the annual building heating load to the peak building heating load:

$$\text{HLH} = \frac{\textit{Annual}\ \text{Heating Load (Btu)}}{\textit{Peak}\ \text{Heating Load (Btu/hr)}}$$

Heating load hours for single family residential buildings were calculated from DOE-2.2 simulations of prototypical single family residential buildings. See section on furnaces above for the HLH values.

Distribution efficiencies for hydronic heating systems are generally higher than ducted systems because leakage is not an issue and the surface area for heat losses is much lower. A value of 1.0 is recommended.

Baseline Efficiencies from which savings are calculated

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

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

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

Notes & References

1. Typical value 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.
2. A distribution system efficiency calculation method for hydronic systems 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 HLH values assumed in this section include a 3°F night time setback of the room temperature setpoint. See the section on programmable setback thermostats and Appendix A for more information.

BOILER RESET CONTROLS

Description of Measure

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

Method for Calculating Energy Savings

$$\Delta\text{therm} = \text{units} \times \text{kBtuh/unit} \times \text{RLF} \times (1 / \bar{\eta}) \times \text{HLH}/100 \times \text{ESF}$$

where:

Δtherm	= gross annual gas savings
units	= number of boiler reset controls installed
kBtuh/unit	= size of boiler served by each reset controller
100	= conversion factor (therm/kBtuh)
$\bar{\eta}$	= average seasonal efficiency of the boiler system without reset controls
RLF	= rated load factor
HLH	= Heating load hours
ESF	= energy savings factor

The ***rated load factor*** is the ratio of the peak heating load imposed on the heating equipment to the total rated heating capacity. This factor compensates for oversizing of the boiler.

$$\text{RLF}_{\text{heat}} = \frac{peak\ \ heating\ \ load}{nameplate\ \ \text{heating}\ \ capacity}$$

Recommended value for the rated load factor is 0.8.

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 load hours are defined as the ratio of the annual building heating load to the peak building heating load:

$$\text{HLH} = \frac{\textit{A}\text{nnual Heating Load (Btu)}}{\textit{Peak}\text{ Heating Load (Btu/hr)}}$$

Heating load hours for residential buildings were calculated from DOE-2.2 simulations of prototypical single family buildings. See section on furnaces above for the appropriate HLH 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 recommended.

Operating Hours

Heating load hours calculated from building energy simulation models 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.

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
2. The HLH values assumed in this section include a 3°F night time setback of the room temperature setpoint. See the section on programmable setback thermostats and Appendix A for more information.

SETBACK THERMOSTAT

Description of Measure

Programmable setback thermostats applied to residential air conditioners, heat pumps, boilers and furnaces.

Method for Calculating Energy Savings

$$\Delta kWh = units \times \left[\frac{ton}{unit} \times RLF_{cool} \times \frac{12}{\overline{EER}_{base} \times \overline{\eta}_{dist,base}} \times CLH \times ESF_{cool} + \frac{kBtuh}{unit} \times RLF_{heat} \times \frac{1}{\overline{COP}_{base} \times \overline{\eta}_{dist,base}} \times \frac{HLH}{3413} \times ESF_{heat} \right]$$

$$\Delta therms = units \times \frac{kBtuh}{unit} \times RLF_{heat} \times \frac{1}{\overline{\eta}_{base} \times \overline{\eta}_{dist,base}} \times \frac{HLH}{100} \times ESF_{heat}$$

where:

ΔkWh	= gross annual energy savings
$\Delta therms$	= 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
$\overline{EER}$	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
CLH	= cooling load hours
RLF	= rated load factor
DF	= demand diversity factor
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)
ESF	= energy savings factor
kBtuh/unit	= the nominal rating of the heating capacity of the heat pumps in kBtu/hr
$\overline{COP}$	= average heating season coefficient of performance of heat pump
$\overline{\eta}$	= average seasonal efficiency of furnace or boiler
$\overline{\eta}_{dist}$	= average seasonal distribution system efficiency
HLH	= heating load hours
RLF_{heat}	= heating mode rated load factor
3.413	= conversion factor (Btu/Wh)

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.

The ***distribution system efficiency*** accounts for losses from the distribution system due to leakage and/or inadequate insulation. See section on duct leakage sealing and insulation for more information.

Baseline Efficiencies from which savings are calculated

The baseline efficiency for air conditioners and heat pumps should be set according to the sections on air conditioner and heat pump efficiency above. Distribution system efficiency ($\bar{\eta}_{dist,base}$) should be set to the unsealed and uninsulated values from the duct leakage sealing section for the appropriate building type.

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 load hours, as described in Appendix A. An assumption of 3°F of night time setback behavior is embedded in the models.

Efficiency from which incentives are calculated

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 load hours calculated from building energy simulation models described in Appendix A and summarized above.

Non-Electric Benefits - Annual Fossil Fuel Savings

N/A

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Notes & References

1. Typical value 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.
2. 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.
3. Baseline thermostat setback assumptions taken from: Conner, C.C. and Lucas, R.L. 1990. *Thermostat Related Behavior and Internal Temperatures Based on Measured Data in Residences.* PNL-7465, Pacific Northwest Laboratory. Richland, WA.
4. The RLW study on thermostat energy savings can be found at http://www.cee1.org/eval/db_pdf/933.pdf
5. Programmable thermostat savings for the cooling season taken from the Energy Star website: www.energystar.gov

REFRIGERANT CHARGE CORRECTION

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

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

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

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
$\overline{EER}$	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
EER_{pk}	= energy efficiency ratio under peak conditions (Btu/watt-hour)
CLH	= cooling load hours
RLF	= rated load factor
DF	= demand diversity factor
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

The **rated load factor** (RLF) is the ratio of the peak cooling load imposed on the cooling equipment to the total rated cooling capacity. This factor compensates for oversizing of the air conditioning unit.

$$RLF = \frac{\text{peak cooling load}}{\text{nameplate capacity}}$$

Cooling load hours are defined as the ratio of the annual building cooling load to the peak building cooling load:

$$CLH = \frac{\text{Annual Cooling Load (Btu)}}{\text{Peak Cooling Load (Btu / hr)}}$$

The ***demand diversity 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 demand diversity factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the rated load factor, demand diversity factor and coincidence factors are shown below:

Parameter	Recommended Values
Rated Load Factor	0.8
Demand diversity factor	0.8
Coincidence factor	1.0

The ***average seasonal cooling efficiency*** ($\overline{\text{EER}}$) 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 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
$\text{EER}_{\text{pk, uncorr}}$	0.9 x $\text{EER}_{\text{pk, corr}}$
$\overline{\text{EER}}_{\text{uncorr}}$	0.9 x $\overline{\text{EER}}_{\text{corr}}$

Cooling load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical residential buildings. See the section on air conditioning above.

<u>Baseline Efficiencies from which savings are calculated</u>
See uncorrected efficiencies listed above.

Compliance Efficiency from which incentives are calculated
See air conditioning and heat pump sections for correctly charged efficiencies by unit vintage.

Operating Hours

Cooling load hours vary by city and building vintage. See air conditioning and heat pump section above.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated

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 demand diversity factor (DF), coincidence factor (CF) and 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
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HIGH EFFICIENCY GAS FURNACES

Description of Measure

High efficiency condensing gas furnaces with AFUE > 92%.

Method for Calculating Energy Savings

$$\Delta\text{therms} = \text{units} \times \frac{\text{kBtuh}}{\text{unit}} \times \text{RLF}_{\text{heat}} \times \left(\frac{1}{\bar{\eta}_{base} \times \bar{\eta}_{duct,base}} - \frac{1}{\bar{\eta}_{ee} \times \bar{\eta}_{duct,ee}} \right) \times \frac{\text{HLH}}{100}$$

where:

Δtherms	= gross annual gas savings
units	= number of furnaces installed
kBtuh/unit	= the nominal rating of the heating capacity of the furnace in kBtu/hr
$\bar{\eta}$	= average seasonal efficiency of furnace
$\bar{\eta}_{\text{duct}}$	= average seasonal duct system efficiency
HLH	= heating load hours
RLF_{heat}	= heating mode rated load factor
100	= conversion factor (kBtuh/therm)

The ***rated load factor*** is the ratio of the peak heating load imposed on the heating equipment to the total rated heating capacity. This factor compensates for oversizing of the furnace.

$$\text{RLF}_{\text{heat}} = \frac{peak\ \ heating\ \ load}{nameplate\ \ \text{heating}\ \ capacity}$$

Recommended value for the rated load factor is 0.8.

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.

The ***duct system efficiency*** accounts for losses from duct systems due to leakage and inadequate insulation. See section on duct leakage sealing and insulation for more information.

Heating load hours are defined as the ratio of the annual building heating load to the peak building heating load:

$$\text{HLH} = \frac{\textit{A}\text{nnual Heating Load (Btu)}}{\textit{Peak}\text{ Heating Load (Btu/hr)}}$$

Heating 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 HLH for three building vintages and six different cities in NY are shown below:

City	Old	Average	New
Albany	1,836	1,724	1,630
Binghamton	1,914	1,813	1,696
Buffalo	1,912	1,841	1,708
Massena	1,982	1,870	1,778
NYC	1,288	1,168	1,076
Syracuse	1,832	1,739	1,622

<u>Baseline Efficiencies from which savings are calculated</u>

The baseline efficiency ($\overline{\eta}_{base}$) 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.

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. See duct leakage sealing and insulation section in this manual for more information.

<u>Compliance Efficiency from which incentives are calculated</u>

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

Operating Hours

Heating load hours calculated from building energy simulation models described in Appendix A and summarized above.

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.

Notes & References

1. Typical value 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.
2. 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
3. The HLH values assumed in this section include a 3°F night time setback of the room temperature setpoint. See the section on programmable setback thermostats and Appendix A for more information.

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

$$\Delta kWh = units \times \left[\frac{ton}{unit} \times RLF_{cool} \times \left[\frac{12}{\overline{EER}_{base} \times \overline{\eta}_{dist,base}} - \frac{12}{\overline{EER}_{ee} \times \overline{\eta}_{dist,ee}} \right] \times CLH + \frac{kBtuh}{unit} \times RLF_{heat} \times \left[\frac{1}{\overline{COP}_{base} \times \overline{\eta}_{dist,base}} - \frac{1}{\overline{COP}_{ee} \times \overline{\eta}_{dist,ee}} \right] \times \frac{HLH}{3413} \right]$$

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

$$\Delta therms = units \times \frac{kBtuh}{unit} \times RLF_{heat} \times \left(\frac{1}{\overline{\eta}_{base} \times \overline{\eta}_{duct,base}} - \frac{1}{\overline{\eta}_{ee} \times \overline{\eta}_{duct,ee}} \right) \times \frac{HLH}{100}$$

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/unit	= the nominal rating of the heating capacity of the furnace or heat pump in kBtu/hr
ton/unit	= the nominal rating of the cooling capacity of the air conditioner or heat pump in tons
$\overline{EER}$	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
EER_{pk}	= energy efficiency ratio under peak conditions (Btu/watt-hour)
$\overline{COP}$	= average heating season coefficient of performance of heat pump
$\overline{\eta}$	= average heating season efficiency of furnace
$\overline{\eta}_{duct}$	= duct system average seasonal efficiency
CLH	= cooling load hours
HLH	= heating load hours

RLF_{cool}	= cooling mode rated load factor
RLF_{heat}	= heating mode rated load factor
DF	= demand diversity factor
CF	= coincidence factor
100	= conversion factor (kBtuh/therm)
3413	= conversion factor (Btu/kwh)

The ***rated load factor*** for cooling is the ratio of the peak cooling load imposed on the cooling equipment to the total rated cooling capacity. This factor compensates for oversizing of the air conditioning unit.

$$RLF_{cool} = \frac{\text{peak cooling load}}{\text{nameplate capacity}}$$

The ***rated load factor*** for heating is the ratio of the peak heating load imposed on the heating equipment to the total rated heating capacity. This factor compensates for oversizing of the furnace.

$$RLF_{heat} = \frac{\textit{peak heating load}}{\textit{nameplate} \text{ heating } \textit{capacity}}$$

Recommended value for the rated load factor is 0.8.

The $\overline{EER}$ 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.

Cooling load hours are defined as the ratio of the building annual cooling load to the building peak cooling load:

$$CLH = \frac{\text{Annual Cooling Load (Btu)}}{\text{Peak Cooling Load (Btu / hr)}}$$

See section on high efficiency air conditioners for more information

Heating load hours are defined as the ratio of the annual building heating load to the peak building heating load:

$$HLH = \frac{\textit{A}\text{nnual Heating Load (Btu)}}{\textit{Peak} \text{ Heating Load (Btu/hr)}}$$

See section on high efficiency heat pumps and furnaces for more information

The ***average seasonal cooling efficiency*** ($\overline{\text{EER}}$) 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 ***average seasonal efficiency*** of the heat pump ($\overline{\text{COP}}$) is the ratio of the heating output to the electricity input (in consistent units) over a heating season. 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. See heat pump section for more information.

The ***average seasonal efficiency*** of the furnace ($\bar{\eta}$) 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.

Duct system efficiencies were calculated utilizing the building energy simulation model described in Appendix A. The cooling and heating season average distribution efficiencies for duct systems in residential buildings across six New York cities are summarized below. Ducts are assumed to run in an unconditioned basement. Note: the seasonal average cooling mode efficiency should be used for the summer peak demand savings calculation until distribution efficiency data for summer peak conditions can be developed.

Distribution System Efficiency in Heating Mode

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.951	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

Distribution System Efficiency in Cooling Mode

Duct total leakage (%)	Duct system R-value (supply and return)	Albany	Binghamton	Buffalo	Massena	NYC	Syracuse
8%	Uninsulated	0.969	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

The ***demand diversity 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 demand diversity factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the rated load factor, demand diversity factor, and coincidence factors are shown below:

Parameter	Recommended Values
Rated Load Factor	0.8
Demand diversity factor	0.8
Coincidence factor	1.0

<u>Baseline Efficiencies from which savings are calculated</u>

The baseline efficiency ($\overline{COP}_{base}$) 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. The US EPA estimates total duct leakage for typical residential construction at 20% of system air flow. Uninsulated ducts are considered to be the baseline condition.

Compliance Efficiency from which incentives are calculated

The measure efficiency ($\overline{COP}_{ee}$) for heat pumps should be set according to the section on efficient heat pumps. The measure efficiency ($\overline{\eta}_{ee}$) for furnaces should be set according to the section on efficient furnaces. Distribution system efficiency ($\overline{\eta}_{dist,ee}$) should be set to the Air Conditioning Contractors of America (ACCA) Quality Installation (QI) Standard specifications:

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

Operating Hours

Heating 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

Notes & References

1. Typical value 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.
2. 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
3. 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
4. The HLH values assumed in this section include a 3°F night time setback of the room temperature setpoint. See the section on programmable setback thermostats and Appendix A for more information.

ROOM AIR CONDITIONER

Description of Measure

Room air conditioners installed in single family residential buildings.

Method for Calculating Summer Peak Demand and Energy Savings

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

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

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
$\overline{EER}$	= average energy efficiency ratio over the cooling season. (Btu/watt-hour)
EER_{pk}	= energy efficiency ratio under peak conditions (Btu/watt-hour)
CLH	= cooling load hours
RLF	= rated load factor
DF	= demand diversity factor
CF	= coincidence factor
12	= conversion factor (kBtuh/ton)

The ***rated load factor*** is the ratio of the peak cooling load imposed on the cooling equipment to the total rated cooling capacity. This factor compensates for oversizing of the air conditioning unit.

$$RLF = \frac{\text{peak cooling load}}{\text{nameplate capacity}}$$

Cooling load hours are defined as the ratio of the building annual cooling load to the building peak cooling load:

$$CLH = \frac{\text{Annual Cooling Load (Btu)}}{\text{Peak Cooling Load (Btu / hr)}}$$

The ***demand diversity 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 demand diversity factor is defined as the average fraction of installed capacity of a population of HVAC systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the rated load factor, demand diversity factor and coincidence factors are shown below:

Parameter	Recommended Values
Rated Load Factor	0.8
Demand diversity factor	0.8
Coincidence factor	1.0

Baseline Efficiencies from which savings are calculated

Baseline efficiency assumptions for normal replacement are shown below:

Product Class (Btu/hr)	Seasonal average efficiency ($\overline{EER}$)	Efficiency under Peak Conditions (EER_{pk})
< 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

Note: seasonal and peak efficiencies are set to the same value until additional information on the seasonal efficiency of room air conditioners can be developed.

Compliance Efficiency from which incentives are calculated

Product Class (Btu/hr)	Energy Star		CEE Tier 1		CEE Tier 2	
	$\overline{EER}$	EER_{pk}	$\overline{EER}$	EER_{pk}	$\overline{EER}$	EER_{pk}
< 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

Operating Hours

See central air conditioner section for operating hours by climate zone and building vintage.

Non-Electric Benefits - Annual Fossil Fuel Savings

None anticipated

Notes & References

1. Typical values for demand diversity factor (DF), coincidence factor (CF) and 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
0

WATER HEATING

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) 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[35] are:

Water Heater Type	Recovery efficiency	Capacity
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 ***demand diversity factor*** is used to account for the fact that not all water heating systems in all buildings in the population are operating at the same time. The demand diversity factor is defined as the average fraction of installed capacity of a population of water heating systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the demand diversity factor and coincidence factors are shown below:

Parameter	**Recommended Values**
Demand diversity factor	1.0
Coincidence factor	1.0

<u>Baseline Efficiencies from which savings are calculated</u>

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

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

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

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.

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.

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 off set 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.

<u>Baseline Efficiencies from which savings are calculated</u>

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

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.

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.

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[36]

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$_{gas}$

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

[36]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

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.

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[37]

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))

Table 1 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.[38]

Table 1. 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$_{elec}$

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

[38] 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

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.

HOT WATER TANK WRAPS

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
$\Delta therm$	= 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 fiberglass 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.

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

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 ***demand diversity factor*** is used to account for the fact that not all water heating systems in all buildings in the population are operating at the same time. The demand diversity factor is defined as the average fraction of installed capacity of a population of water heating systems that are operating at the time of the end-use peak.

The ***coincidence factor*** is used to account for the fact that peak measure savings may not be coincident with utility peak demands. The coincidence factor is defined as the portion of the end-use demand reduction that is coincident with the system peak.

Recommended values for the demand diversity factor and coincidence factors are shown below:

Parameter	Recommended Values
Demand diversity factor	1.0
Coincidence factor	1.0

<u>Baseline Efficiencies from which savings are calculated</u>

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	
$\Delta therm$		18.1

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.

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

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.

CUSTOM MEASURES

Measure Description

The term "custom" is used to describe any measure not specifically covered by a prescribed approach for estimating measure-level kWh or kW savings. Custom measures are project-based. That is, the savings are projected for a specific project rather than a group of projects. Whole-building analysis for comprehensive home energy retrofits will be treated as a custom measure. Projects involving multiple commonly applied measures do not need to conduct the analysis on a measure by measure basis, but must limit the scope of the project to measures that have been initially established as generally cost-effective, or of nominal cost.

Custom measures are typically segregated into two estimation categories; those that are weather sensitive (also called weather dependant) and those that are not weather sensitive. Savings from weather sensitive measures involve savings calculations that are based on normal weather conditions within a given geographical area. Custom measures that are not weather sensitive, but are similar in type, size, function and user conditions can be expected to have similar energy impacts regardless of where they are installed.

Savings Estimation Approach

Weather Sensitive Measures. Estimating weather sensitive measures involves the use of climate data applicable to the geographical area in which the measure is installed. Typically this is the long term average weather data most appropriate for the location. To estimate savings, the calculation must first establish the baseline condition for a give set of equipment, operational conditions and weather. Next the post installation consumption is estimated for the equipment and operational conditions that apply to the new equipment under the same weather conditions. The difference in kWh and/ or therm consumption between the estimated baseline energy use and the post-installation estimated consumption is defined as the custom project estimated savings. For projects in which savings can be affected by customer use and application conditions, the savings are adjusted for expected changes in those conditions.

Non-Weather Sensitive Measures. Non-weather sensitive custom measures do not need to adjust savings for normal or expected weather. The consumption calculations for the energy use of the baseline condition are compared to the consumption calculations for the custom project's post-installation conditions. The savings estimates must account for changes in the post-installation conditions if applicable.

kW Savings.

kW savings calculations for weather sensitive measures may be conducted using the peak temperature conditions contained within the long-term average weather data or ASHRAE

1% design conditions appropriate for the site. For all measures, an appropriately derived coincidence factor must be used to adjust project peak demand savings to the grid kW savings at the summer peak hour.

Documentation Requirements

Custom project savings calculations must include all engineering equations along with a list input parameters. Computer software used to estimate project savings must be identified, with the software maker and version number. The data source for each engineering parameter or computer model input must be referenced. Documentation on software algorithms must be available for review.

Project Review

The Department will review custom project calculations prior to acceptance and approval. The general methodology for recurring custom projects using a consistent savings estimation approach will be approved prior to project initiation. Individual or one-time projects will be reviewed and approved individually. Thorough documentation of all critical assumptions and formulae must be supplied with each project to facilitate an accurate and timely review.

APPENDIX A. PROTOTYPICAL BUILDING DESCRIPTIONS

SINGLE FAMILY RESIDENTIAL

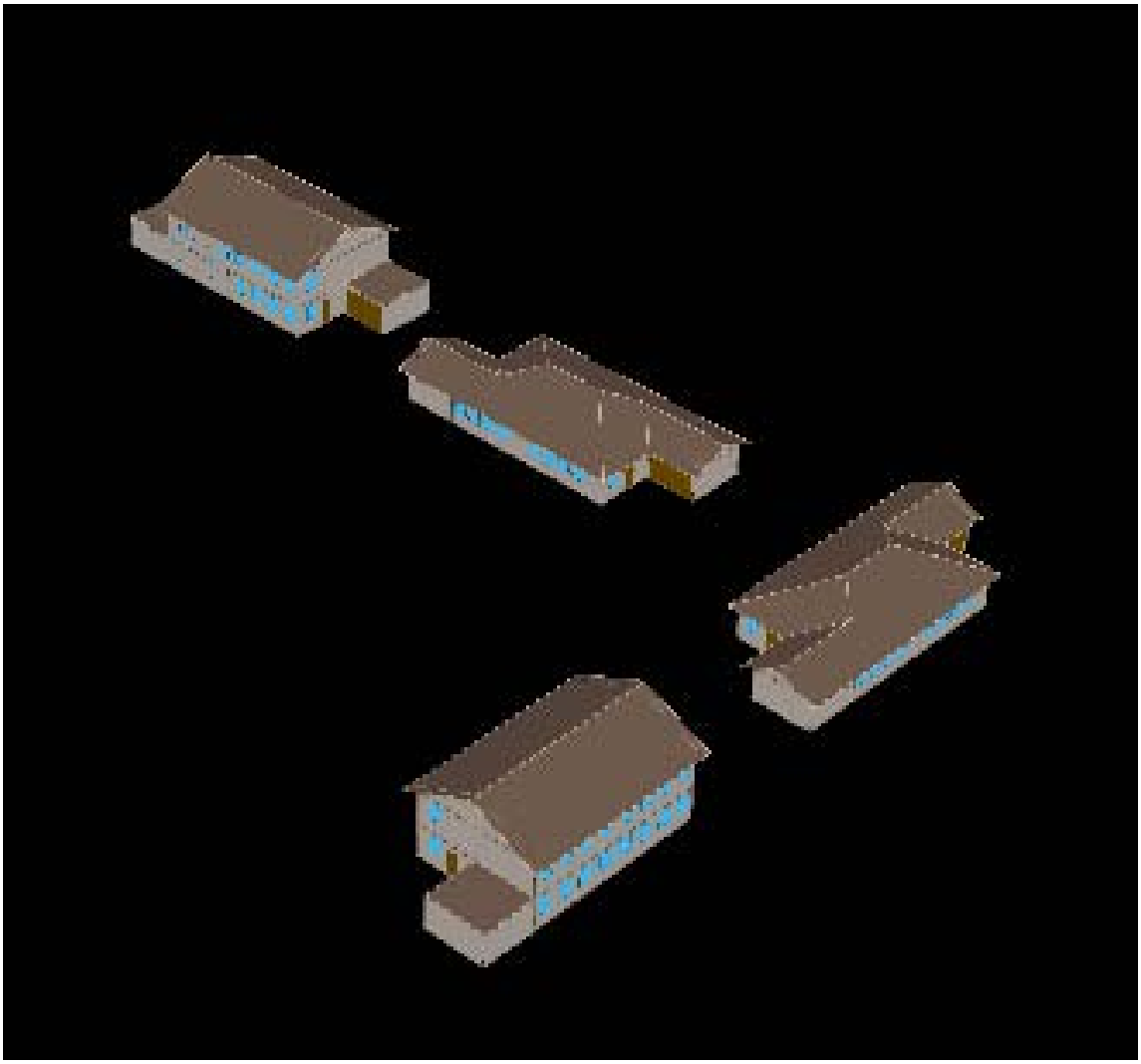
Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[39] study, with adjustments made for local building practices and climate. The prototype "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.

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

1. Old, poorly insulated building constructed in the 1950s or earlier. This vintage is referred to as the "old" vintage
2. Existing, average insulated building conforming to 1980s era building codes. This vintage is referred to as the "average" vintage.
3. New construction conforming to the NY State energy standards for residential buildings. This vintage is referred to as the "new" vintage.

A sketch of the residential prototype buildings is shown below.

[39] 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 residential building prototypical DOE-2 model.

The general characteristics of the residential building prototype model are summarized below:

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

Characteristic	Value
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% oversizing.
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 in Table 2 through Table 3

Table 2. 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

Table 3. 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 in Table 4.

Table 4. 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 in Table 5.

Table 5. 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.