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

Selected Residential & Small Commercial Measures

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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 that are funded via the Systems Benefits Charge.

As evaluations are conducted the approaches will be revised and up-dated so that they move toward high levels of estimation accuracy. Other measures will be added as necessary.

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 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 point in time when 50% of the measures are expected to be removed or no longer functional, which include 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	Sector	Effective Useful Life	Source
CFL LIGHT BULB	Single Family Residential	Coupon - 5 Direct Install - 7 Markdown - 7	New England SPWG[1]
CFL LIGHT FIXTURE	Single Family Residential	7	Residential Lighting Measure Life Study[2]
ELECTRIC HEAT PUMP WATER HEATER	Single Family Residential	10	DEER[3]
CENTRAL AIR CONDITIONING	Single Family Residential	15	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] 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.
[3] 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	Sector	Effective Useful Life	Source
CENTRAL HEAT PUMPS	Single Family Residential	15	DEER
REFRIGERANT CHARGE CORRECTION	Single Family Residential	10	DEER
REFRIGERATOR LEDS	Commercial	3.5	US DOE[4]
EVAPORATOR FAN CONTROLS	Commercial	16	DEER
VENDING MACHINE CENTRAL CONTROLS	Commercial	5	DEER
ANTI-SWEAT HEATER CONTROLS	Commercial	12	DEER
HIGH EFFICIENCY PACKAGED AIR CONDITIONERS	Commercial	15	DEER
PACKAGED HEAT PUMPS	Commercial	15	DEER
REFRIGERANT CHARGE CORRECTION	Commercial	10	DEER
COOL ROOF	Commercial	15	DEER
ECONOMIZER	Commercial	10	DEER
EFFICIENT AIR-COOLED REFRIGERATION CONDENSER	Commercial	15	DEER
HIGH PERFORMANCE GLAZING	Commercial	20	
REFRIGERATED CASE NIGHT COVERS	Commercial	5	DEER
WINDOW FILM	Commercial	10	DEER

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 freeriders and spillover.

Freerider adjustments act to erode the gross savings estimate by subtracting out the savings that would have occurred without the program's incentive or influence. Spillover adjustments act to 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 freeriders, plus the addition

[4] LED life estimated based on 8760 hours per year of operation and 30,000 hour measure life. See "Lifetime of White LEDs," USDOE. www.netl.doe.gov/ssl/PDFs/lifetimeWhiteLEDs_aug16_r1.pdf.

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. At the current time, to standardize the net impact estimation approach, a net to gross conversion factor of 0.90 will be applied to the gross saving estimates.

RESIDENTIAL MEASURES

CFL LIGHT BULB – RESIDENTIAL (SINGLE FAMILY)

Measure Description

An EnergyStar compliant screw-based CFL bulb whose wattage is known. Programs with this characteristic include direct install, catalog, instant and mail-in coupon, 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 purchase of light bulbs is diffuse, through many product sources (drug stores, supermarkets, hardware stores, discount stores, etc.), and are purchased by large numbers of 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 CLF). The alternative approach is to use a method that avoids the determination of the baseline for each recorded CLF by assuming that that the CFL bulb purchased is one of the standard replacement products for the incandescent, in terms of light output equivalency (see http://www.energystar.gov/index.cfm?c=cfls.pr_cfls). The method is to assume that the baseline is an incandescent light source with a wattage which is 3.4 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 bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

Δ Watts = 2.4 x CFL wattage. This is based on an "incandescent to CFL" wattage ratio of 3.4 to 1.

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.[5] 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.[6] 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.

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	19.6	**19**	53.3
8	22.4	**20**	56.1
9	25.2	**21**	58.9
10	28.0	**22**	61.7
11	30.8	**23**	64.5
12	33.6	**24**	67.3
13	36.4	**25**	70.1
14	39.2	**26**	72.9
15	42.0	**27**	75.7
16	44.9	**28**	78.5
17	47.7	**29**	81.3
18	50.5	**30**	84.1

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

[5] "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1.
[6] 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.[7]

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

[7] Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007, p. III.

Massachusetts Electric Company, NSTAR Electric, Fitchburg G&E by Nexus Market Research Inc., and RLW Analytics Inc., Oct 1, 2004

"Extended residential logging results" memo to Angela Li, National Grid, by Tom Ledyard, RLW Analytics Inc., and Lynn Hoefgen, Nexus Market Research Inc., May 2, 2005

Market Progress and Evaluation Report for the 2005 Massachusetts ENERGY STAR Lighting Program, prepared for Cape Light Compact, National Grid – Massachusetts, NSTAR, Western Massachusetts Electric Company by Nexus Market Research Inc, RLW Analytics, Inc., Shel Feldman Management Company, Dorothy Conant. September 29, 2006

Process and Impact Evaluation of the Efficiency Maine Lighting Program, prepared for Efficiency Maine by Nexus Market Research Inc. and RLW Analytics Inc., April 10, 2007

Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures - For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), prepared for the New England State Program Working Group by RLW Analytics Inc., Spring 2007

CFL LIGHT FIXTURE – RESIDENTIAL (SINGLE FAMILY)

Measure Description

An Energy Star hardwired interior fluorescent fixture with pin based bulbs 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 (the hours-of-use typically varies between pin and screw-based bulbs).

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 purchase of light bulbs is diffuse, through many product sources (drug stores, supermarkets, hardware stores, discount stores, etc.), and are purchased by large numbers of 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 CLF). The alternative approach is to use a method that avoids the determination of the baseline for each recorded CLF by assuming that that the CFL bulb purchased is one of the standard replacement products for the incandescent, in terms of light output equivalency (see http://www.energystar.gov/index.cfm?c=cfls.pr_cfls). The method is to assume that the baseline is an incandescent light source with a wattage which is 3.4 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 bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

Δ Watts = 2.4 x CFL wattage. This is based on an "incandescent to CFL" wattage ratio of 3.4 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.[8] The Connecticut 2008 Program Savings Documentation uses 2.6 hours per

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

day, based on a 2003 Connecticut-based study. A study of the 2005-2006 residential lighting program for Efficiency Maine reports daily hours of use at 2.4 for interior fixtures.[9] 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	15.3	**19**	41.6
8	17.5	**20**	43.8
9	19.7	**21**	46.0
10	21.9	**22**	48.2
11	24.1	**23**	50.4
12	26.3	**24**	52.6
13	28.5	**25**	54.8
14	30.7	**26**	56.9
15	32.9	**27**	59.1
16	35.0	**28**	61.3
17	37.2	**29**	63.5
18	39.4	**30**	65.7

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 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

[9] 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.

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.[10]

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

[10] 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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ELECTRIC HEAT PUMP WATER HEATER EF GREATER THAN 2 – RESIDENTIAL SINGLE FAMILY

Measure Description

An electric heat pump water heater is a domestic water heater that uses a heat pump technology for moving heat from the air (inside or outside the home) to the water storage tank. The heat pump is essentially 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. When air conditioning is required, the 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.

Savings Estimation Approach

1. New Construction, Replace on Failure and Early Replacement

This savings will be estimated as follows:

<u>Annual kWh Savings</u>

Annual Energy Savings = (estimated baseline electric hot water energy consumption) - (estimated heat pump energy consumption for same water volumes and temperature conditions) = (estimated electric savings) + (positive or negative impacts on the home's heating and cooling system under average participant household conditions).

Total Energy Impacts[11] = (BE – HPWH) + HCI

Where: BE = Baseline electric energy consumption. If new construction, the baseline is the typical system that would have been installed without the program. If a replace on failure system, the baseline is the typical system would have been installed without the program. If it is an early replacement, the baseline is the typical system that was removed for the remaining useful life of the system, plus

[11] See FEMP Federal Technology Alert for Residential Water Heat Pump Water Heaters for detailed calculation approach. All temperature and environmental conditions will use New York specific temperature data. See page 32 of the FEMP publication for water input temperatures for New York. Typical historic temperatures should be used for heating and cooling degree days.

the savings associated with the system that would have been installed without the program based on market averages.
HPWH = Heat pump electric water heating consumption
HCI = Heating and cooling impact. The negative or positive impacts on the homes heating and cooling systems. If electric, the impacts are embedded in the calculation. If other than electric impacts, the impacts are reported separately (see below).

If participant's homes are heated or cooled with electricity, the impacts on the water heating estimate are adjusted to account for increases or decreases on the home's heating and cooling systems. If the participant's homes are heated by non-electric fuels, the impacts of the water heating system on the home's heating and cooling energy use are also reported. This will require multi-fuel impact reporting when non-electric heated homes are allowed to be participants.

Energy savings calculations will be estimated following FEMP's [12] Federal Technology Alert
http://www1.eere.energy.gov/femp/pdfs/FTA_res_heat_pump.pdf Appendix C, Calculations (page 31) for the typical program installation condition. Heating and cooling degree days will be the typical condition for the typical installation for the program participants.

Peak Savings

Peak savings calculation will follow FEMP's Technical Alert Appendix C approach for summer afternoon peak conditions for New York reflective of the typical conditions that apply to the program service area as a whole, weighted to the participant distribution across the state.

Sample Calculation

Inserted below is the sample calculation presented in FEMP's Technical Alert. However, this calculation is for a warmer climate than what New York experiences. The inputs for water temperature and climate will be based on typical program conditions for the typical installation (See following page).

[12] FEMP = Federal Energy Management Program

Sample Calculation Approach (from Appendix C of FEMP's Technical Alert.

Calculations
("eq" followed by individual numbers in brackets refer to results of the equation identified by the number)

(1) Hot-water Usage Estimate (Number of Occupants -1) x 10.7 gal/day/occupant + 32.2 gal/day) _____ gal/day
(2) Daily Hot-water Energy Load = 8.28 Btu/gal x _____ gal/day x (135-CW supply temperature) _____ Btu/day

HPWH EF
If supplemental electric resistance heat not anticipated
(3a) $EF_{hpwh} = EF_{base}$

If supplemental electric resistance heat anticipated
(3b) $EF_{hpwh} = EF_{base} \times (1 - FLR) + FLR$

Where FLR = Tank Size (gal) x 0.25 x 8.28 Btu/gal-°F x (135°F - CW supply temperature) x 25%/(eq2)

Annual Hot-water Energy Requirements

$$\textit{Annual Electric Energy} = \frac{\textit{Hot Water Energy Load (Btu/day)}}{\textit{Water Heater EF}} \times \frac{\textit{365 days/yr}}{\textit{3413 Btu/kWh}}$$

(4) Electric Resistance Water Heater _____ kWh/yr
(5) Heat Pump Water Heater _____ kWh/yr

Annual Space conditioning effect of ambient-air HPWHs

(6) DF = [A x HR65 + (1-A) x HR80)] / (HR65)

where A = 2 x (Design 2.5% T_{wb} °F/ Design 2.5% T_{db} °F) - 0.9
HR65 = number of hours per year with outdoor temperature > 65°F = _____ hr/yr
HR80 = number of hours per year with outdoor temperature > 80°F = _____ hr/yr

(7) Beneficial Space Cooling = DF x HR65 x (eq2) / 24 hr/day x ($1/EF_{ac}$ -$1/EF_{hpwh}$) / 1000 = _____ kBtu/yr
(8) Detrimental Space Cooling = (8760-HR65) x (eq2) / 24 hr/day x ($1/EF_{ac}$ -$1/EF_{hpwh}$) /1000 = _____ kBtu/yr

(9) Annual Space Cooling Energy Savings= (eq7)/(SEER) = _____ kWh/yr
(10) Annual Additional Space Heating Energy
(10a) Electric Resistance Heat= (eq8)/(3.413 kBtu/kWh) = _____ kWh/yr
(10b) Electric Heat Pump= (eq8)/HSPF kBtu/kWh) = _____ kWh/yr
(10c) Gas Heat= (eq8)/(EFF * 10) = _____ therms/yr

Annual Energy Requirements:
Electric Resistance Water Heater
(11) Electric Energy = (eq4) = _____ (kWh/yr

Heat Pump Water Heater
(12a)Electric Energy = (eq5) - (eq9) + (eq10a) + (eq10b) = _____ kWh/yr
(12b)Gas Energy = (eq10c) _____ therms/yr

Contribution to Demand (non-morning demand peak)
(13) Electric Resistance Water Heater Demand (kW) = (eq4) / 8760 hr/yr x 12 mo/yr = _____ kW-mo/yr
(14) HPWH Demand = (eq5) / 8760 hr/yr x 12 mo/yr = _____ kW-mo/yr

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RESIDENTIAL CENTRAL AIR CONDITIONING

Description of Measure

Central air conditioning systems with rated efficiency of 14 SEER or higher in Single Family Residential applications.

Method for Calculating Summer Peak Demand and Energy Savings

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

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

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.

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

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.

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

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

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

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

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:

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

where:

EFLH = equivalent full-load hours
$\overline{\text{EER}}$ = 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)
Central Air conditioner	Early replacement baseline	SEER 10	9.2
	Replace on failure baseline	SEER 13	11.09
	Measure	SEER 14	11.99
		SEER 15	12.72
		SEER 16	11.61
		SEER 17	12.28
Central Heat Pump	Early replacement baseline	SEER 10	9.0
	Replace on failure baseline	SEER 13	11.07
	Measure	SEER 14	11.72
		SEER 15	12.32
		SEER 16	12.06
		SEER 17	12.52
		SEER 18	12.80

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.

Cooling load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical residential buildings. The prototype building characteristics are described in Appendix A. Residential prototypes for three different classes of building vintage were developed:

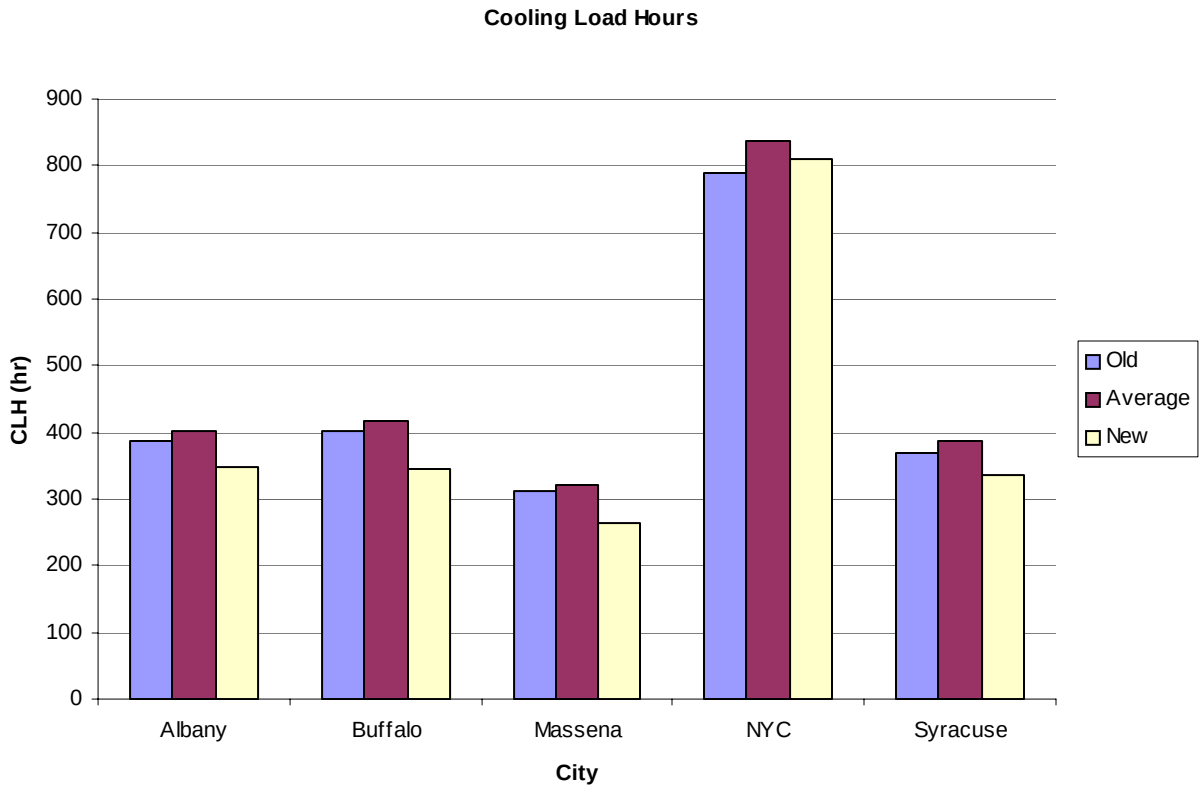
1. Old, poorly insulated building constructed in the 1950s or earlier. This vintage is referred to as the “old” vintage
2. Existing, average insulated building conforming to 1980s era building codes. This vintage is referred to as the “average” vintage.
3. New construction conforming to current NY state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

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

Cooling Load Hours by Vintage and City

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

These data are also shown in the following Figure:



Note that the CLH are generally lower for new buildings, and that the CLH for old and average buildings are fairly consistent between Albany, Buffalo and Syracuse. CLH values are lower for Massena and much higher for New York City.

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

Incremental Cost

TBD

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.

Revision Number

0

RESIDENTIAL CENTRAL HEAT PUMPS

Description of Measure

A heat pump with improved heating season performance factor (HSPF). Note only the heating savings is presented here; cooling savings from an efficient heat pump is the same as the cooling savings for an efficient air conditioner.

Method for Calculating Annual Energy Savings

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

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)
Early replacement baseline	SEER 10	6.8
Replace on failure baseline	SEER 13	8.1
Measure	SEER 14	8.6
	SEER 15	8.8

	Cooling Seasonal Efficiency (SEER)	Heating Seasonal Efficiency (HSPF)
	SEER 16	8.4
	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.

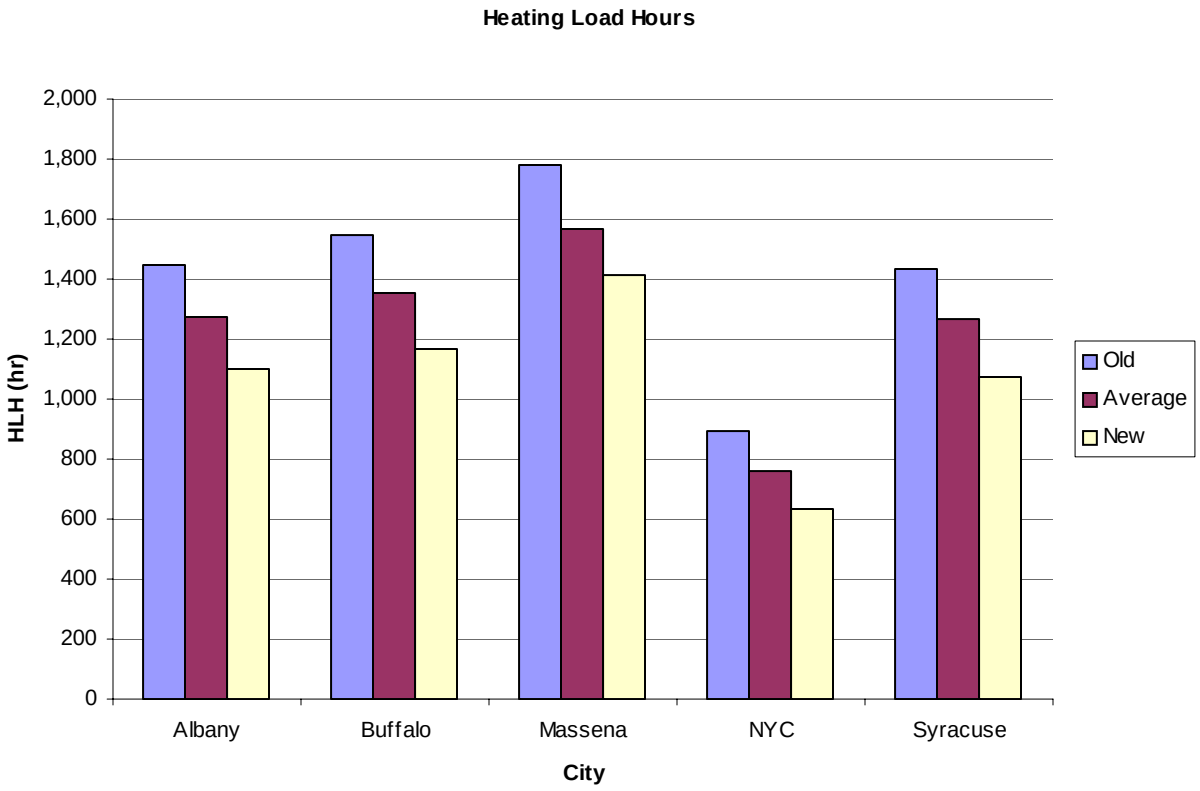
Heating load hours are defined as the ratio of the annual building heating load to the peak building heating load:

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

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 five different cities in NY are shown below:

City	Old	Average	New
Albany	1,450	1,275	1,100
Buffalo	1,544	1,354	1,166
Massena	1,780	1,566	1,414
NYC	893	763	635
Syracuse	1,436	1,265	1,075

These data are also shown in the following Figure:



Note: the heating load hours decrease with newer buildings. As with the CLH, HLH are fairly comparable for Albany, Buffalo and Syracuse. New York City has much lower HLH, while Massena HLH are higher.

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

TBD

Operating Hours

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

Incremental Cost

TBD

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
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RESIDENTIAL 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 ***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.

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

AC Unit Efficiency Assumptions

Type	Seasonal Average Efficiency (SEER)	Efficiency under peak conditions (EER)
Air conditioner	SEER 10	9.2
	SEER 13	11.09
	SEER 14	11.99
	SEER 15	12.72
	SEER 16	11.61
	SEER 17	12.28
Air Source Heat Pump	SEER 10	9.0
	SEER 13	11.07
	SEER 14	11.72
	SEER 15	12.32
	SEER 16	12.06
	SEER 17	12.52
	SEER 18	12.80

Refrigerant charge adjustments applied to existing units should use the SEER 10 data. Adjustments to new units should use the SEER of the unit treated.

Refrigerant charge adjustments are assumed to have a 10% improvement in unit efficiency. That is, the efficiency of an uncorrected unit is 10% below that of a corrected unit.

Parameter	Recommended Values
$EER_{pk,\ uncorr}$	$0.9 \times EER_{pk,\ corr}$
$\overline{EER}_{uncorr}$	$0.9 \times \overline{EER}_{corr}$

Cooling load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical residential buildings. The prototype building characteristics are described in Appendix A. Residential prototypes for three different classes of building vintage were developed:

1. Old, poorly insulated 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 five different cities in NY are shown below:

Cooling Load Hours by Vintage and City

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

Baseline Efficiencies from which savings are calculated
See table above.

Compliance Efficiency from which incentives are calculated
TBD

Operating Hours

Cooling load hours vary by city and building vintage. See table above.

Incremental Cost

TBD

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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SMALL COMMERCIAL MEASURES

REFRIGERATOR LEDs – SMALL COMMERCIAL

Measure Description
The installation of LED bulbs in commercial display refrigerators, coolers or freezers. The light bulbs in a typical refrigerator, cooler or freezer add to the load on that unit by increasing power consumption of the unit when the light is on, and by adding heat to the inside of the unit that must be overcome thought additional cooling. Replacing incandescent and fluorescent lighting with low heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of waste heat generated from the lighting that must be overcome by the unit's compressor cycles.

Savings Estimation Approach

Annual Savings

kWh Savings
The savings approach is based on the estimated difference in refrigerator / cooler / freezer consumption before the change-out compared to the unit consumption after the change-out for the period of time the unit is turned on during a typical year of operation.

The estimation approach is as follows:

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

Where:

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

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

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

Where:

ComEffFac = 1.52 for coolers and 1.66 for freezers * 0.8 for the portion of the saved energy that would have needed to be eliminated via the compressor[13]. Thus, ComEffFac for refrigerators and coolers = (1.52 * .8) = 1.2 and ComEffFac for freezers = (1.66 * .8) = 1.33.

kW Savings

Peak demand savings are calculated using the following approach.

KW = (kW B – kW A)* Compressor factor

Where:

KW = the total average kW savings of the refrigeration system, including both the kW reduction due to the bulb replacement and the kW reduced from the operation of the compressor not having to remove the excess lighting.
kW B = The total power usage of the lighting fixtures that are being replaced, kW.
kW A = The total power usage of the new lighting fixtures that are being installed,
Compressor factor = 1.52 for coolers and 1.66 for freezers. The factors are based on effective refrigeration compressor EER values of 6.7 and 5.25 Btu/Wh, respectively.

[13] Note: It is assumed that 0.2 of the saved energy escapes via conduction through the display case and does not have to be recaptured by the compressor. This adjustments should be confirmed via metering tests and adjusted when those tests have been concluded.

EVAPORATOR FAN CONTROLS – SMALL COMMERCIAL AND SMALL INDUSTRIAL

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

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

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

<u>kWh Savings</u>
Annual kWh savings = (Hs * kW)
Where:

Hs = Annual hours per year shut off by the control system
kW = kW demand for the typical fan shut off (included system efficiency adjustments)

<u>kW Savings</u>
The units are expected to be operating at peak period. Peak savings are estimated as follows:

Peak demand savings = D * kW
Where:

D = diversity factor (typically about 10%)
kW = kW draw of operating fan

VENDING MACHINE CENTRAL CONTROLS – SMALL COMMERCIAL AND SMALL INDUSTRIAL

Measure Description

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

Savings Estimation Approach

kWh Savings

The savings approach is based on the estimated difference in machine consumption between a unit operating full time and operating only during controlled on-cycles. The estimation approach is as follows:[14]

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

Where:

> Annual kWh B = The total annual kWh usage of the vending machines that are being controlled without the control system installed.
> Annual kWh A = The total annual kWh usage of the vending machines with the control system installed.

Because different vending machines have different operational characteristics, consumption of the vending machines will need to be estimated for the pre-installation period for the typical program-covered unit. Where possible, this estimate should be based on a metered sample of units operated with kWh/kW meters to establish the baseline conditions. If metered data of a sample of machines in New York is not available, metered samples from other states or programs can be used. If metered data from other states are not available, manufacturer's data on unit consumption can be used. The consumption of the units for the baseline condition will be assumed to operate 8,760hours per year. Savings for the post-installation period will be estimated using the percent of time the units are turned on as a fraction of the total estimated consumption for 8,760 hours per year.

kW savings

Because the units typically operate during peak hours in the baseline condition, the peak demand reduction will be set at the average on-time duty-cycle adjusted kW draw of the typical unit. The typical kW draw will be estimated using the metered kW draw of the

unit (if a metered sample is available) in a non-controlled condition. If meter sample data is not available, manufactures data of kW draw and estimated duty-cycle can be used. Thus, if the unit consumes X kW and is operating on a 50% duty cycle, the peak kW savings would be X/.5 or 1/2X.

CUSTOM MEASURES – SMALL COMMERCIAL AND SMALL INDUSTRIAL

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 that can be projected are for a specific project rather than a group of projects.

Custom measures are typically segregated into two estimation categories; those that are weather sensitive (also called weather dependant) measures 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. For example, weather sensitive measures installed in up-state New York will have different savings than those same measures installed in a different climate zone, such as in New York City where the climate is buffered by the thermal effects of the Atlantic Ocean and the Gulf Stream. 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
<u>kWh Savings</u>

Weather Sensitive
Estimating weather sensitive measures involves the use of climate adjustments that apply for the geographical area in which the measure is installed. In general, the savings for weather sensitive custom measures are based on project-specific consumption calculations taking into account the energy consumption of the baseline equipment and operating environment and the expected equipment and operating environment of the post-installation condition. These calculations are based on a specific set of weather conditions that apply to that individual project. To estimate savings, the calculation must first establish the baseline condition for a give set of equipment, operational conditions and weather. Typically this is "normal-weather" for a location based on the average daily weather over 30 or 40 years. For expediency, the state can be broken down into climate zones so that there are only a few pre-defined "typical" climate zones so that the same weather data is used for all custom projects within the same weather zone regardless of the utility or organization conducting the program or the service territory in which that program is offered. 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 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
Non-weather sensitive custom measures do not need to adjust savings for normal or expected weather. In these cases 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. In these cases the savings estimates are adjusted for expected changes in the post-installation conditions. However, in most cases the pre and post installation conditions are not significantly different enough to require adjustments for changing conditions. However, this assumption needs to be documented in the estimate of savings.

kW Savings[15]
Weather Sensitive Measures:
The methodology used to determine the annual kWh savings for temperature-dependent measures depends on the type of analysis used to estimate savings. Savings from temperature-dependent measures are typically determined by either full load hour analysis, bin temperature analysis, or a detailed computer simulation. The following will be the procedure used to estimate the kWh savings for these measures:

When annual savings are calculated using a full load hour analysis, an appropriately derived coincidence factor will be used for a measure that has a connected load that can be determined from rated or nameplate data. Demand savings will be the connected load kW savings times the appropriate coincidence factor. When using a temperature bin analysis to calculate the energy savings, the demand (kW) savings are averaged over the appropriate temperature bins. When a computer simulation is used to calculate savings, the demand savings will be averaged over the
appropriated peak time period.

Non Weather Sensitive Measures:
Demand savings for measures that are not temperature-dependent will be determined by estimating the average estimated savings at the coincident peak time. For example, for a process VFD measure, the savings will depend on cycling of the load. This cycling may occur many times during an hour. If the process is operating throughout the summer period, the average demand savings will be:

(annual kWh savings)/(annual equivalent full load hours of operation).

If the process is operated only a portion of that time period the demand savings will be prorated based on that portion.

[15] This portion of the savings estimate approach is based on the Connecticut Energy Efficiency Funds Program Savings Documentation approach for 2008 published by Connecticut Light and Power Company.

ANTI-SWEAT HEATER CONTROLS

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings
ΔkW_S = qty doors × (ΔkW/door) × DF_S × CF_S

Gross Annual Energy Savings
ΔkWh = qty doors × (ΔkWh/door)

Δtherm = qty doors × (Δtherm/door)

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
qty doors	= quantity of reach-in freezer doors controlled
DF	= demand diversity factor
CF	= coincidence factor
ΔkW/door	= electricity demand savings per reach-in freezer doors controlled
ΔkWh/door	= electricity consumption savings per reach-in freezer doors controlled

The ***demand diversity factor*** is used to account for the fact that not all anti-sweat heaters 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 control 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 factor are shown below:

Parameter	Value
Demand diversity factor	1.0
Coincidence factor	1.0

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a prototypical grocery store. The prototype building characteristics are described in

Appendix A. The unit energy and demand savings for five different cities in NY are shown below

Unit Energy and Demand Savings for Anti-sweat Heater Controls

Climate	Units	kWh/unit	kW/unit
Albany	per door	1850	0
Buffalo	per door	1843	0
Massena	per door	1896	0
NYC	per door	1764	0
Syracuse	per door	1784	0

Baseline Efficiencies from which savings are calculated

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

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

The control system is assumed to be active 24/7

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

Controlling door anti-sweat heaters increases space heating requirements. The therm impacts are shown below:

Δtherm = qty doors $\times$ (Δtherm/door)

where:

Δtherm/door = gas consumption change per reach-in freezer doors controlled

Therm impacts per unit are shown below:

Antisweat Heater Control Therm Impacts

Climate	Units	therm/unit
Albany	per door	-15
Buffalo	per door	-13
Massena	per door	-16

Climate	Units	therm/unit
NYC	per door	-13
Syracuse	per door	-11

Notes & References

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

Revision Number
0

C&I HIGH EFFICIENCY PACKAGED AIR CONDITIONERS

Description of Measure

Rooftop and split system AC in small commercial building applications.

Method for Calculating Summer Peak Demand and Energy Savings

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

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

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 annual cooling load to the 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 is defined as follows:

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

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. EFLH are converted to CLH using the following equation:

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

where:

EFLH = equivalent full-load hours
$\overline{\text{EER}}$ = 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

Recommended values from the 2004-5 DEER update study for baseline and measure efficiency are shown in the table below:

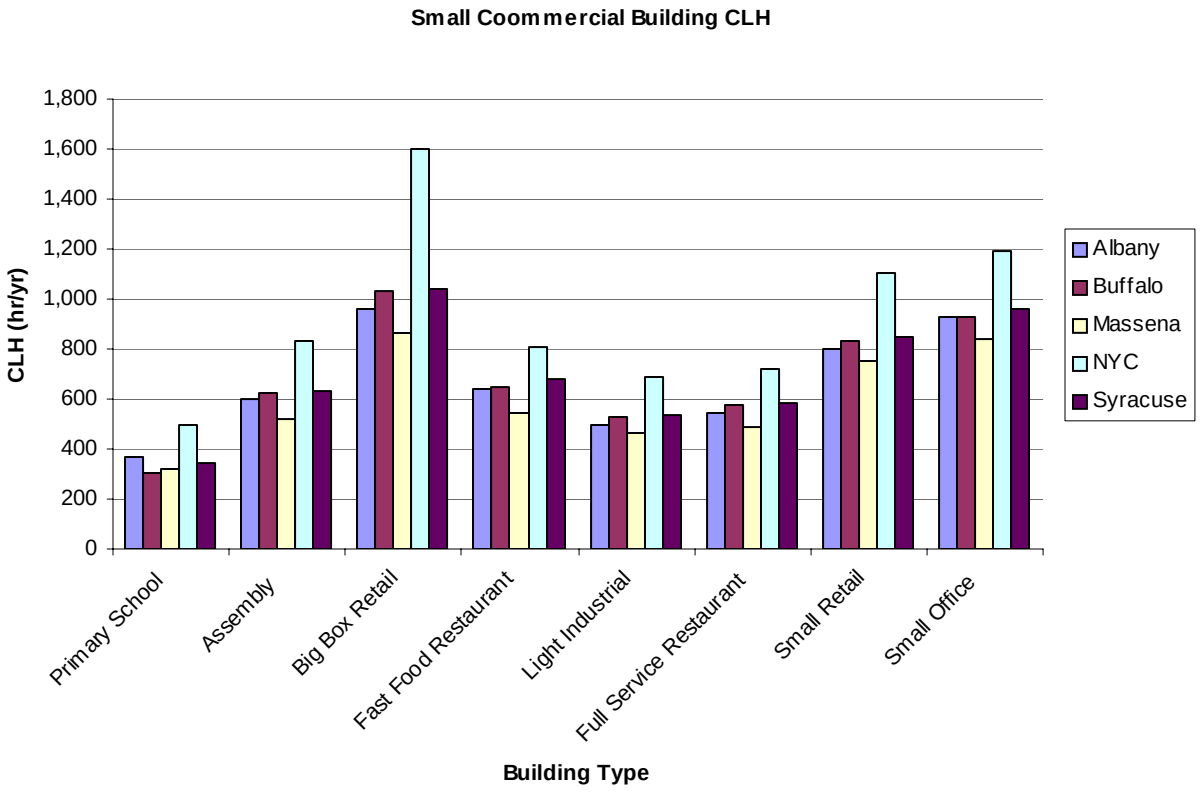
Baseline and Measure Performance Assumptions

Equipment Category	Capacity Range (Btu/hr)	Baseline Efficiency		Measure Efficiency	
		Average	Peak	Average	Peak
Unitary A/C (1) phase	<65,000 1 Ph	13.0	11.1	14.0	12.2
Unitary A/C (3) phase	<65,000 3 Ph	12.0	10.4	13.0	11.1
Unitary A/C (3) phase	65,000 - 135,000	9.1	10.1	9.6	11.0
Unitary A/C (3) phase	135,000 - 240,000	8.5	9.5	9.5	11.0
Unitary A/C (3) phase	240,000 - 760,000	8.4	9.3	8.9	10.0
Unitary A/C (3) phase	>760,000	8.1	9.0	8.9	10.0
Unitary HP (1) phase	<65,000 1 Ph	13.0	11.1	14.0	12.2
Unitary HP (3) phase	<65,000 3 Ph	12.0	10.4	13.0	11.1
Unitary HP (3) phase	65,000 - 135,000	8.8	9.9	9.5	11.0
Unitary HP (3) phase	135,000 - 240,000	8.2	9.1	8.8	10.0
Unitary HP (3) phase	>240,000	8.0	8.8	8.8	10.0

Cooling load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The CLH for eight building types and five different cities in NY are shown below:

Building	Albany	Buffalo	Massena	NYC	Syracuse
Primary School	371	305	321	492	342
Assembly	597	621	519	836	632
Big Box Retail	961	1,033	860	1,599	1,039
Fast Food Restaurant	640	649	545	806	680
Light Industrial	500	529	463	686	536
Full Service Restaurant	546	575	486	718	583
Small Retail	803	833	749	1,102	848
Small Office	927	931	839	1,194	960

These data are also shown in the Figure below.



Note that the CLH vary widely depending on the building type and climate. Within each building type, the CLH for are fairly consistent between Albany, Buffalo and Syracuse, with lower values for Massena and much higher values for New York City.

Baseline Efficiencies from which savings are calculated

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

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

The operating hours by climate zone and building type are shown in the Table above

Incremental Cost

TBD

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
0

C&I PACKAGED HEAT PUMPS

Description of Measure

A heat pump with improved heating season performance factor (HSPF). Note only the heating savings is presented here; cooling savings from an efficient heat pump is the same as the cooling savings for an efficient air conditioner.

Method for Calculating Annual Energy Savings

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

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 RLF 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:

Equipment Type	Size Range	Baseline Heating Seasonal Efficiency (HSPF)	Measure Heating Seasonal Efficiency (HSPF)
Unitary HP (1) phase	<65,000 1 Ph	8.1	8.6
Unitary HP (3) phase	<65,000 3 Ph	7.7	8.1
Unitary HP (3) phase	65,000 - 135,000		
Unitary HP (3) phase	135,000 - 240,000		
Unitary HP (3) phase	>240,000		

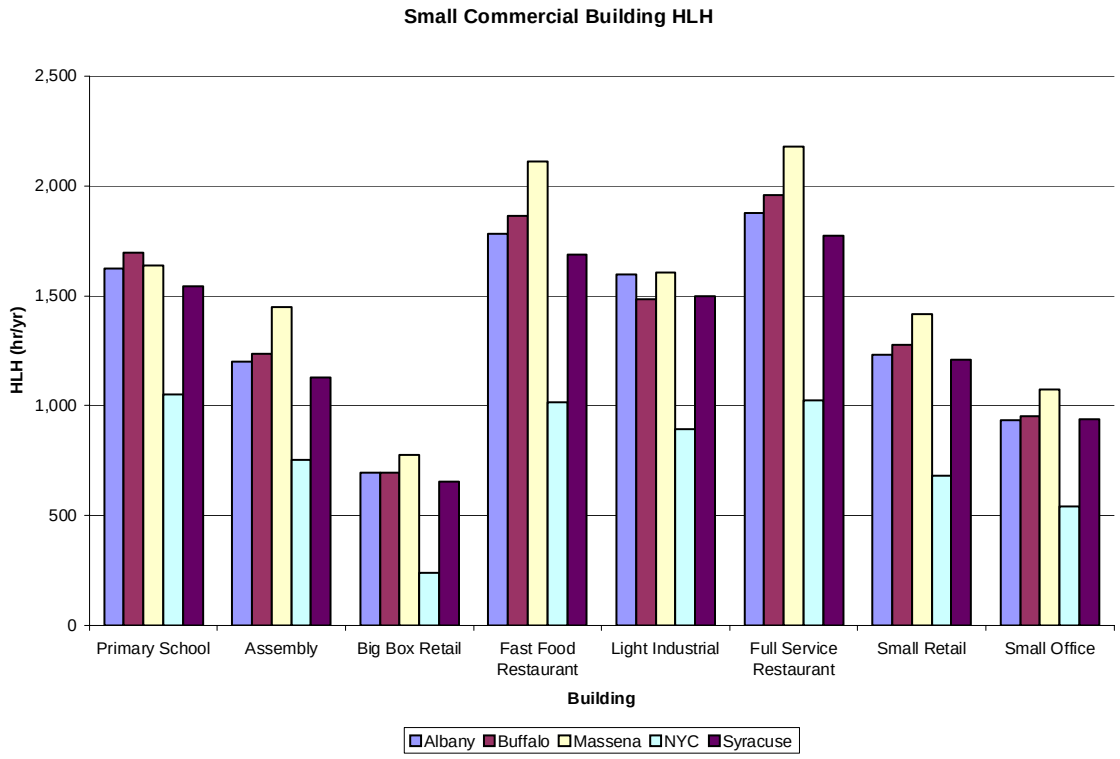
Heating load hours are defined as the ratio of the annual building heating load to the peak building heating load:

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

Heating load hours were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The HLH for three building vintages and five different cities in NY are shown below:

Building	Albany	Buffalo	Massena	NYC	Syracuse
Primary School	1,625	1,696	1,639	1,050	1,545
Assembly	1,201	1,237	1,448	754	1,129
Big Box Retail	693	696	775	239	653
Fast Food Restaurant	1,782	1,864	2,112	1,016	1,689
Light Industrial	1,597	1,485	1,607	892	1,500
Full Service Restaurant	1,878	1,959	2,182	1,026	1,774
Small Retail	1,230	1,275	1,417	681	1,211
Small Office	934	950	1,076	539	938

These data are also shown in the following figure.



Note that the HLH vary widely depending on the building type and climate. Within each building type, the HLH for are fairly consistent between Albany, Buffalo and Syracuse, with higher values for Massena and much lower values for New York City.

Baseline Efficiencies from which savings are calculated

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

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

Heating load hours vary by building type and city. See table above.

Incremental Cost

TBD

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

C&I REFRIGERANT CHARGE CORRECTION

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

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

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

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*** 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.

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

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

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

Baseline and Measure Performance Assumptions

Equipment Category	Capacity Range (Btu/hr)	Efficiency	
		Average	Peak
Unitary A/C (1) phase	<65,000 1 Ph	13.0	11.1
Unitary A/C (3) phase	<65,000 3 Ph	12.0	10.4
Unitary A/C (3) phase	65,000 - 135,000	9.1	10.1
Unitary A/C (3) phase	135,000 - 240,000	8.5	9.5
Unitary A/C (3) phase	240,000 - 760,000	8.4	9.3
Unitary A/C (3) phase	>760,000	8.1	9.0
Unitary HP (1) phase	<65,000 1 Ph	13.0	11.1
Unitary HP (3) phase	<65,000 3 Ph	12.0	10.4
Unitary HP (3) phase	65,000 - 135,000	8.8	9.9
Unitary HP (3) phase	135,000 - 240,000	8.2	9.1
Unitary HP (3) phase	>240,000	8.0	8.8

Refrigerant charge adjustments are assumed to have a 10% improvement in unit efficiency. That is, the efficiency of an uncorrected unit is 10% below that of a corrected unit.

Parameter	Recommended Values
$EER_{pk,\ uncorr}$	$0.9 \times EER_{pk,\ corr}$
$\overline{EER}_{uncorr}$	$0.9 \times \overline{EER}_{corr}$

Cooling load hours for residential buildings were calculated from a DOE-2.2 simulation of prototypical small commercial buildings. The prototype building characteristics are described in Appendix A. The CLH for eight building types and five different cities in NY are shown below:

Building	Albany	Buffalo	Massena	NYC	Syracuse
Primary School	371	305	321	492	342
Assembly	597	621	519	836	632
Big Box Retail	961	1,033	860	1,599	1,039
Fast Food Restaurant	640	649	545	806	680
Light Industrial	500	529	463	686	536
Full Service Restaurant	546	575	486	718	583
Small Retail	803	833	749	1,102	848
Small Office	927	931	839	1,194	960

Baseline Efficiencies from which savings are calculated

The baseline (uncorrected) efficiency is assumed to be 10% lower than the nominal (corrected) unit efficiency.

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

The operating hours by climate zone and building type are shown above

Incremental Cost

TBD

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
0

COOL ROOF

Description of Measure

Roofing material with reduced solar absorptance. The cool roof is assumed to have a solar absorptance of 0.3 compared to a standard roof with solar absorptance of 0.8.

Method for Calculating Summer Peak Demand and Energy Savings

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

Gross Annual Energy Savings
$\Delta kWh = kSF\ cool\ roof \times (\Delta kWh/kSF)$

where:

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

The ***demand diversity factor*** is used to account for the fact that not all HVAC systems in all buildings where cool roofs 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.

DF = 0.8
CF = 1.0

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

Building Type	City	Unit	KWh/unit	KW/unit

Assembly	Albany	1000 sq ft roof area	138	0.071
Assembly	Buffalo	1000 sq ft roof area	119	0.056
Assembly	Massena	1000 sq ft roof area	135	0.065
Assembly	NYC	1000 sq ft roof area	168	0.059
Assembly	Syracuse	1000 sq ft roof area	150	0.088
Big Box Retail	Albany	1000 sq ft roof area	155	0.124
Big Box Retail	Buffalo	1000 sq ft roof area	132	0.067
Big Box Retail	Massena	1000 sq ft roof area	150	0.083
Big Box Retail	NYC	1000 sq ft roof area	950	-0.150
Big Box Retail	Syracuse	1000 sq ft roof area	165	0.106
Fast Food	Albany	1000 sq ft roof area	117	0.050
Fast Food	Buffalo	1000 sq ft roof area	101	0.050
Fast Food	Messina	1000 sq ft roof area	124	0.050
Fast Food	NYC	1000 sq ft roof area	170	0.000
Fast Food	Syracuse	1000 sq ft roof area	131	0.050
Full Service Restaurant	Albany	1000 sq ft roof area	279	0.200
Full Service Restaurant	Buffalo	1000 sq ft roof area	233	0.150
Full Service Restaurant	Massena	1000 sq ft roof area	282	0.150
Full Service Restaurant	NYC	1000 sq ft roof area	344	0.050
Full Service Restaurant	Syracuse	1000 sq ft roof area	307	0.250
Light Industrial	Albany	1000 sq ft roof area	90	0.073
Light Industrial	Buffalo	1000 sq ft roof area	74	0.080
Light Industrial	Massena	1000 sq ft roof area	87	0.096
Light Industrial	NYC	1000 sq ft roof area	118	0.055
Light Industrial	Syracuse	1000 sq ft roof area	102	0.135
Primary School	Albany	1000 sq ft roof area	196	0.624
Primary School	Buffalo	1000 sq ft roof area	152	0.426
Primary School	Massena	1000 sq ft roof area	191	0.116
Primary School	NYC	1000 sq ft roof area	270	0.652
Primary School	Syracuse	1000 sq ft roof area	202	0.506
Small Office	Albany	1000 sq ft roof area	151	0.080
Small Office	Buffalo	1000 sq ft roof area	130	0.040
Small Office	Massena	1000 sq ft roof area	152	0.080
Small Office	NYC	1000 sq ft roof area	169	0.040
Small Office	Syracuse	1000 sq ft roof area	157	0.060
Small Retail	Albany	1000 sq ft roof area	175	0.109
Small Retail	Buffalo	1000 sq ft roof area	143	0.078
Small Retail	Massena	1000 sq ft roof area	164	0.125
Small Retail	NYC	1000 sq ft roof area	203	0.062
Small Retail	Syracuse	1000 sq ft roof area	184	0.109

Baseline Efficiencies from which savings are calculated

The baseline condition is assumed to be roofing material with a solar absorptance of 0.8

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

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

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

Reducing roofing material solar absorptance increases space heating requirements. The therm impacts are shown below:

Δtherm = kSF cool roof $\times$ (Δtherm/kSF)

where:

Δtherm/kSF = gas consumption impact per thousand square foot of cool roof installed over a heated space.

The therm impacts per unit are shown below:

Building Type	City	Unit	Therm/unit
Assembly	Albany	1000 sq ft roof area	-16
Assembly	Buffalo	1000 sq ft roof area	-16
Assembly	Massena	1000 sq ft roof area	-19
Assembly	NYC	1000 sq ft roof area	-11
Assembly	Syracuse	1000 sq ft roof area	-18
Big Box Retail	Albany	1000 sq ft roof area	-11
Big Box Retail	Buffalo	1000 sq ft roof area	-10
Big Box Retail	Massena	1000 sq ft roof area	-14
Big Box Retail	NYC	1000 sq ft roof area	-61
Big Box Retail	Syracuse	1000 sq ft roof area	-12
Fast Food	Albany	1000 sq ft roof area	-28
Fast Food	Buffalo	1000 sq ft roof area	-24
Fast Food	Messina	1000 sq ft roof area	-25
Fast Food	NYC	1000 sq ft roof area	-19
Fast Food	Syracuse	1000 sq ft roof area	-28
Full Service Restaurant	Albany	1000 sq ft roof area	-47
Full Service Restaurant	Buffalo	1000 sq ft roof area	-40

Building Type	City	Unit	Therm/unit
Full Service Restaurant	Massena	1000 sq ft roof area	-47
Full Service Restaurant	NYC	1000 sq ft roof area	-30
Full Service Restaurant	Syracuse	1000 sq ft roof area	-47
Light Industrial	Albany	1000 sq ft roof area	-20
Light Industrial	Buffalo	1000 sq ft roof area	-18
Light Industrial	Massena	1000 sq ft roof area	-21
Light Industrial	NYC	1000 sq ft roof area	-14
Light Industrial	Syracuse	1000 sq ft roof area	-20
Primary School	Albany	1000 sq ft roof area	-29
Primary School	Buffalo	1000 sq ft roof area	-27
Primary School	Massena	1000 sq ft roof area	-32
Primary School	NYC	1000 sq ft roof area	-22
Primary School	Syracuse	1000 sq ft roof area	-33
Small Office	Albany	1000 sq ft roof area	-12
Small Office	Buffalo	1000 sq ft roof area	-11
Small Office	Massena	1000 sq ft roof area	-14
Small Office	NYC	1000 sq ft roof area	-8
Small Office	Syracuse	1000 sq ft roof area	-14
Small Retail	Albany	1000 sq ft roof area	-17
Small Retail	Buffalo	1000 sq ft roof area	-15
Small Retail	Massena	1000 sq ft roof area	-21
Small Retail	NYC	1000 sq ft roof area	-12
Small Retail	Syracuse	1000 sq ft roof area	-18

Notes & References

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

Revision Number

0

ECONOMIZER

Description of Measure

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

Method for Calculating Energy Savings

Gross Annual Energy Savings
$\Delta kWh = \text{cooling tons} \times (\Delta kWh/\text{ton})$

where:

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

No peak demand savings are expected from this measure.

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

Building Type	City	unit	KWh/unit
Assembly	Albany	ton	39
Assembly	Buffalo	ton	45
Assembly	Massena	ton	33
Assembly	NYC	ton	27
Assembly	Syracuse	ton	42
Fast Food	Albany	ton	49
Fast Food	Buffalo	ton	53
Fast Food	Messina	ton	44
Fast Food	NYC	ton	39
Fast Food	Syracuse	ton	49
Full Service Restaurant	Albany	ton	38
Full Service Restaurant	Buffalo	ton	41
Full Service Restaurant	Massena	ton	32
Full Service Restaurant	NYC	ton	31
Full Service Restaurant	Syracuse	ton	38
Light Industrial	Albany	ton	45
Light Industrial	Buffalo	ton	38

Building Type	City	unit	KWh/unit
Light Industrial	Massena	ton	33
Light Industrial	NYC	ton	25
Light Industrial	Syracuse	ton	54
Primary School	Albany	ton	49
Primary School	Buffalo	ton	52
Primary School	Massena	ton	38
Primary School	NYC	ton	42
Primary School	Syracuse	ton	41
Small Office	Albany	ton	202
Small Office	Buffalo	ton	195
Small Office	Massena	ton	188
Small Office	NYC	ton	186
Small Office	Syracuse	ton	186
Small Retail	Albany	ton	107
Small Retail	Buffalo	ton	113
Small Retail	Massena	ton	95
Small Retail	NYC	ton	95
Small Retail	Syracuse	ton	111

Baseline Efficiencies from which savings are calculated

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

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

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

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

No therm impacts are anticipated from this measure

Notes & References

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

Revision Number
0

EFFICIENT AIR-COOLED REFRIGERATION CONDENSER

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings
ΔkW_S = compressor tons $\times$ (ΔkW/ton) $\times$ $DF_S \times CF_S$

Gross Annual Energy Savings
ΔkWh = compressor tons $\times$ (ΔkWh/ton)

where:

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

The ***demand diversity factor*** is used to account for the fact that refrigeration 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 refrigeration 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.

The recommended values for demand diversity and coincidence factors are shown below:

Factor	Recommended Value
DF	1.0
CF	1.0

Unit energy and demand savings were calculated from a DOE-2.2 simulation of a prototypical grocery store. The prototype building characteristics are described in Appendix A. The unit energy and demand savings for five different cities in NY are shown below:

City	Unit	KWh /unit	KW/unit
Albany	per ton of compressor capacity	1296	0.136
Buffalo	per ton of compressor capacity	1297	0.103
Massena	per ton of compressor capacity	1301	0.123
NYC	per ton of compressor capacity	1220	0.152
Syracuse	per ton of compressor capacity	1283	0.149

Baseline Efficiencies from which savings are calculated

The baseline condition is assumed to a standard efficiency air-cooled refrigeration system condenser, with a 20ºF approach temperature on low temperature applications and a 15ºF approach temperature on medium temperature applications. Standard efficiency specific fan power of 45 Btu/hr of heat rejection capacity per watt of fan power.

Compliance Efficiency from which incentives are calculated

Must provide an efficient air-cooled refrigeration system condenser, with an approach temperature of 13ºF or less on low temperature applications and an approach temperature of 8ºF or less on medium temperature applications. Specific fan power must be greater than or equal to 85 Btu/hr of heat rejection capacity per watt of fan power.

Operating Hours

The refrigeration system is assumed to be active 24/7

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

No therm impacts anticipated for this measure

Notes & References

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

Revision Number
0

HIGH PERFORMANCE GLAZING

Description of Measure

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

Method for Calculating Summer Peak Demand and Energy Savings

Gross Summer Coincident Demand Savings
ΔkW_S = Glazing area (100 SF) $\times$ (ΔkW/100 SF) $\times$ $DF_S \times CF_S$

Gross Annual Energy Savings
ΔkWh = Glazing area (100 SF) $\times$ (ΔkWh/ 100 SF)

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
Glazing area	= Aperture area of glazing system in 100 SF
DF	= demand diversity factor
CF	= coincidence factor
ΔkW/100 SF	= electricity demand savings per 100 SF of glazing area
ΔkWh/100 SF	= electricity consumption savings per 100 SF of glazing area

The ***demand diversity factor*** is used to account for the fact that not all HVAC systems in all buildings where high performance glazing systems 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.

DF = 0.8
CF = 1.0

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

Building Type	City	Unit	KWh/unit	KW/unit
Big Box Retail	Albany	100 sqft glazing	283	0.169

Building Type	City	Unit	KWh/unit	KW/unit
Big Box Retail	Buffalo	100 sqft glazing	251	0.158
Big Box Retail	Massena	100 sqft glazing	277	0.236
Big Box Retail	Syracuse	100 sqft glazing	288	0.191
Fast Food	Albany	100 sqft glazing	297	0.086
Fast Food	Buffalo	100 sqft glazing	282	0.189
Fast Food	Messina	100 sqft glazing	285	0.086
Fast Food	NYC	100 sqft glazing	384	0.017
Fast Food	Syracuse	100 sqft glazing	304	0.207
Full Service Restaurant	Albany	100 sqft glazing	226	0.103
Full Service Restaurant	Buffalo	100 sqft glazing	214	0.138
Full Service Restaurant	Massena	100 sqft glazing	225	0.120
Full Service Restaurant	NYC	100 sqft glazing	282	0.034
Full Service Restaurant	Syracuse	100 sqft glazing	240	0.155
Light Industrial	Albany	100 sqft glazing	267	0.203
Light Industrial	Buffalo	100 sqft glazing	227	0.226
Light Industrial	Massena	100 sqft glazing	223	0.226
Light Industrial	NYC	100 sqft glazing	331	0.136
Light Industrial	Syracuse	100 sqft glazing	240	0.248
Primary School	Albany	100 sqft glazing	564	0.328
Primary School	Buffalo	100 sqft glazing	536	0.175
Primary School	Massena	100 sqft glazing	536	0.151
Primary School	NYC	100 sqft glazing	688	0.308
Primary School	Syracuse	100 sqft glazing	549	0.385
Small Office	Albany	100 sqft glazing	312	0.206
Small Office	Buffalo	100 sqft glazing	282	0.140
Small Office	Massena	100 sqft glazing	295	0.201
Small Office	NYC	100 sqft glazing	366	0.136
Small Office	Syracuse	100 sqft glazing	306	0.153
Small Retail	Albany	100 sqft glazing	358	0.186
Small Retail	Buffalo	100 sqft glazing	319	0.177
Small Retail	Massena	100 sqft glazing	332	0.224
Small Retail	NYC	100 sqft glazing	431	0.168
Small Retail	Syracuse	100 sqft glazing	362	0.214

Baseline Efficiencies from which savings are calculated

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

Compliance Efficiency from which incentives are calculated

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

Operating Hours

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

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

Reducing the solar heat gain coefficient increases space heating requirements, while reducing the U-value decreases space heating requirements. The net therm impacts are calculated as follows:

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

where:

Δtherm/ 100 SF = gas consumption impact per 100 square foot of glazing.

The therm impacts per unit are shown below:

Building Type	City	Unit	Therm/unit
Assembly	Albany	100 sqft glazing	85
Assembly	Buffalo	100 sqft glazing	84
Assembly	Massena	100 sqft glazing	183
Assembly	NYC	100 sqft glazing	30
Assembly	Syracuse	100 sqft glazing	69
Big Box Retail	Albany	100 sqft glazing	61
Big Box Retail	Buffalo	100 sqft glazing	64
Big Box Retail	Massena	100 sqft glazing	79
Big Box Retail	Syracuse	100 sqft glazing	63
Fast Food	Albany	100 sqft glazing	81
Fast Food	Buffalo	100 sqft glazing	94
Fast Food	Messina	100 sqft glazing	89
Fast Food	NYC	100 sqft glazing	65
Fast Food	Syracuse	100 sqft glazing	83
Full Service Restaurant	Albany	100 sqft glazing	56
Full Service Restaurant	Buffalo	100 sqft glazing	69
Full Service Restaurant	Massena	100 sqft glazing	62
Full Service Restaurant	NYC	100 sqft glazing	52
Full Service Restaurant	Syracuse	100 sqft glazing	65
Light Industrial	Albany	100 sqft glazing	45
Light Industrial	Buffalo	100 sqft glazing	48

Building Type	City	Unit	Therm/unit
Light Industrial	Massena	100 sqft glazing	48
Light Industrial	NYC	100 sqft glazing	21
Light Industrial	Syracuse	100 sqft glazing	39
Primary School	Albany	100 sqft glazing	60
Primary School	Buffalo	100 sqft glazing	73
Primary School	Massena	100 sqft glazing	69
Primary School	NYC	100 sqft glazing	44
Primary School	Syracuse	100 sqft glazing	62
Small Office	Albany	100 sqft glazing	43
Small Office	Buffalo	100 sqft glazing	51
Small Office	Massena	100 sqft glazing	52
Small Office	NYC	100 sqft glazing	30
Small Office	Syracuse	100 sqft glazing	45
Small Retail	Albany	100 sqft glazing	65
Small Retail	Buffalo	100 sqft glazing	74
Small Retail	Massena	100 sqft glazing	72
Small Retail	NYC	100 sqft glazing	42
Small Retail	Syracuse	100 sqft glazing	70

Notes & References

1. Glazing properties taken from ASHRAE Handbook of Fundamentals
2. High performance glass conforms to ASHRAE Standard 90.1 – 2004.

Revision Number

0

REFRIGERATED CASE NIGHT COVERS

Description of Measure

Night covers installed on medium temperature open multi-deck cases in grocery stores to reduce energy consumption by reducing infiltration into the case during unoccupied hours. The analysis assumes a night cover is deployed 4 hours per night, reducing store air infiltration into the case by 50%.

Method for Calculating Energy Savings

Gross Annual Energy Savings
$\Delta kWh = LF \text{ of case} \times (\Delta kWh/LF)$

where:

ΔkWh = gross annual energy savings
LF of cover = Lineal feet of case fitted with a night cover
$\Delta kWh/SF$ = electricity consumption savings per LF of case

No summer peak demand savings are expected from this measure.

Unit energy savings were calculated from a DOE-2.2 simulation of a prototypical grocery store. The prototype building characteristics are described in Appendix A. The unit energy savings for five different cities in NY are shown below:

City	Unit	KWh/unit
Albany	per lineal foot	27
Buffalo	per lineal foot	28
Massena	per lineal foot	28
NYC	per lineal foot	29
Syracuse	per lineal foot	27

Baseline Efficiencies from which savings are calculated

The baseline condition is assumed to be no night covers installed

Compliance Efficiency from which incentives are calculated

TBD

Operating Hours

The night curtains are assumed to be deployed 4 hours per night.

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

Installing night covers reduces space heating requirements, since the introduction of cold air into the conditioned space is reduced. The therm impacts are calculated as follows:

Δtherm = LF case $\times$ (Δtherm/LF)

where:

Δtherm/LF = gas consumption change per lineal foot of case

Therm impacts per unit are shown below:

City	Unit	Therm/unit
Albany	per lineal foot	2
Buffalo	per lineal foot	5
Massena	per lineal foot	2
NYC	per lineal foot	1
Syracuse	per lineal foot	4

Notes & References

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

Revision Number
0

WINDOW FILM

Description of Measure

Window films with reduced solar heat gain coefficient applied to single pane clear glass in small commercial buildings

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)

where:

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

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.

DF = 0.8
CF = 1.0

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

Building	City	Unit	KWh/unit	KW/unit
Assembly	Massena	100 sqft glazing	268	0.090

Building	City	Unit	KWh/unit	KW/unit
Assembly	Syracuse	100 sqft glazing	436	0.190
Fast Food	Albany	100 sqft glazing	286	0.086
Fast Food	Buffalo	100 sqft glazing	263	0.189
Fast Food	Messina	100 sqft glazing	270	0.086
Fast Food	NYC	100 sqft glazing	390	0.017
Fast Food	Syracuse	100 sqft glazing	299	0.172
Full Service Restaurant	Albany	100 sqft glazing	180	0.103
Full Service Restaurant	Buffalo	100 sqft glazing	160	0.138
Full Service Restaurant	Massena	100 sqft glazing	168	0.120
Full Service Restaurant	NYC	100 sqft glazing	244	0.034
Full Service Restaurant	Syracuse	100 sqft glazing	187	0.138
Light Industrial	Albany	100 sqft glazing	265	0.203
Light Industrial	Buffalo	100 sqft glazing	215	0.158
Light Industrial	Massena	100 sqft glazing	222	0.226
Light Industrial	NYC	100 sqft glazing	352	0.136
Light Industrial	Syracuse	100 sqft glazing	266	0.271
Primary School	Albany	100 sqft glazing	448	0.246
Primary School	Buffalo	100 sqft glazing	380	0.399
Primary School	Massena	100 sqft glazing	396	0.189
Primary School	NYC	100 sqft glazing	558	0.272
Primary School	Syracuse	100 sqft glazing	413	0.470
Small Office	Albany	100 sqft glazing	334	0.188
Small Office	Buffalo	100 sqft glazing	292	0.153
Small Office	Massena	100 sqft glazing	302	0.188
Small Office	NYC	100 sqft glazing	406	0.127
Small Office	Syracuse	100 sqft glazing	319	0.171
Small Retail	Albany	100 sqft glazing	345	0.177
Small Retail	Buffalo	100 sqft glazing	303	0.168
Small Retail	Massena	100 sqft glazing	293	0.214
Small Retail	NYC	100 sqft glazing	440	0.140
Small Retail	Syracuse	100 sqft glazing	334	0.205

Baseline Efficiencies from which savings are calculated

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

Compliance Efficiency from which incentives are calculated

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

Operating Hours

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

Incremental Cost

TBD

Non-Electric Benefits - Annual Fossil Fuel Savings

Reducing the solar heat gain coefficient through the application of window films increases space heating requirements. The net therm impacts are calculated as follows:

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

where:

Δtherm/ 100 SF = gas consumption impact per 100 square foot of glazing.

The therm impacts per unit are shown below:

Building Type	City	Unit	Therm/unit
Assembly	Massena	100 sqft glazing	-91
Assembly	Syracuse	100 sqft glazing	-66
Fast Food	Albany	100 sqft glazing	-85
Fast Food	Buffalo	100 sqft glazing	-77
Fast Food	Messina	100 sqft glazing	-83
Fast Food	NYC	100 sqft glazing	-73
Fast Food	Syracuse	100 sqft glazing	-77
Full Service Restaurant	Albany	100 sqft glazing	-69
Full Service Restaurant	Buffalo	100 sqft glazing	-62
Full Service Restaurant	Massena	100 sqft glazing	-66
Full Service Restaurant	NYC	100 sqft glazing	-60
Full Service Restaurant	Syracuse	100 sqft glazing	-62
Light Industrial	Albany	100 sqft glazing	-69
Light Industrial	Buffalo	100 sqft glazing	-72
Light Industrial	Massena	100 sqft glazing	-75
Light Industrial	NYC	100 sqft glazing	-63
Light Industrial	Syracuse	100 sqft glazing	-64
Primary School	Albany	100 sqft glazing	-103
Primary School	Buffalo	100 sqft glazing	-98
Primary School	Massena	100 sqft glazing	-107
Primary School	NYC	100 sqft glazing	-100
Primary School	Syracuse	100 sqft glazing	-101
Small Office	Albany	100 sqft glazing	-47
Small Office	Buffalo	100 sqft glazing	-44
Small Office	Massena	100 sqft glazing	-52

Building Type	City	Unit	Therm/unit
Small Office	NYC	100 sqft glazing	-36
Small Office	Syracuse	100 sqft glazing	-44
Small Retail	Albany	100 sqft glazing	-72
Small Retail	Buffalo	100 sqft glazing	-68
Small Retail	Massena	100 sqft glazing	-84
Small Retail	NYC	100 sqft glazing	-63
Small Retail	Syracuse	100 sqft glazing	-70

Notes & References

1. Window film properties taken from ASHRAE Handbook of Fundamentals

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APPENDIX A PROTOTYPICAL BUILDING DESCRIPTIONS

Single family residential

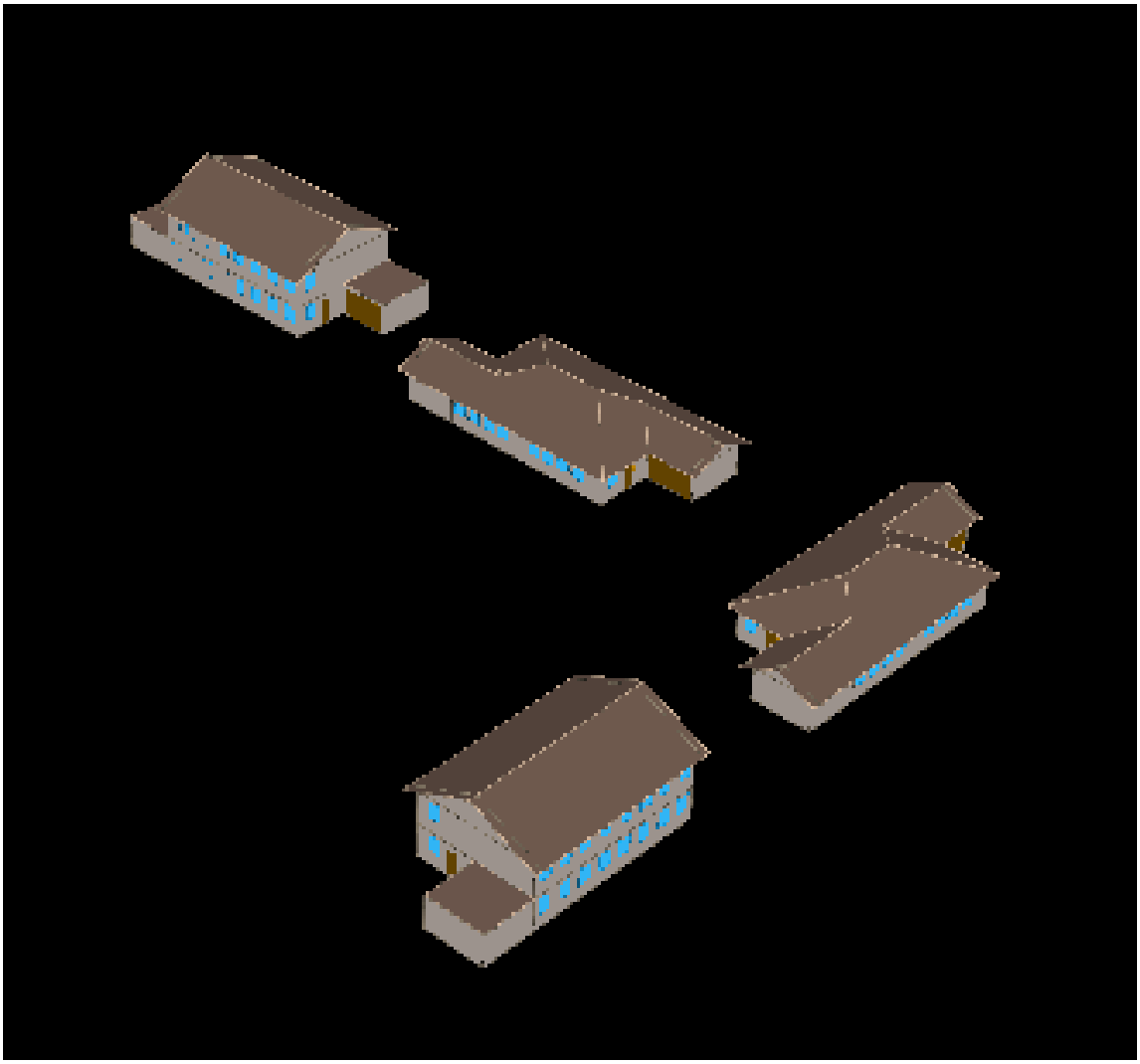
Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[16] study, with adjustments make 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:

4. Old, poorly insulated building constructed in the 1950s or earlier. This vintage is referred to as the "old" vintage
5. Existing, average insulated building conforming to 1980s era building codes. This vintage is referred to as the "average" vintage.
6. 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.

[16] 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	Average of single and double pane; properties vary by vintage

Characteristic	Value
Lighting and appliance power density	0.51 W/SF average
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% oversizing.
HVAC system efficiency	Baseline SEER = 13
Thermostat setpoints	Heating: 70°F with setback to 60°F Cooling: 75°F with setup to 80°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	7	No insulation in 2 by 4 wall; 3.5 in. air gap resistance only
Existing, average insulation	11	Fiberglass insulation in 2 by 4 wall per MEC 1980
New construction	19	Code

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	0.68	0.77	Double pane clear
New construction	0.28	.49	Double low e per code

Infiltration

Infiltration rate assumptions were set by vintage as shown 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.

Small Retail

A prototypical building energy simulation model for a small retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the small retail building prototype are summarized in Table 6.

Table 6. Small Retail Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	6400 square foot sales area 1600 square foot storage area 8000 square feet total
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales area: 3.4 W/SF Storage area: 0.9 W/SF
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	10 – 10 Monday-Saturday 10 – 8 Sunday
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 – 250 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the small retail building prototype is shown in Figure 1.

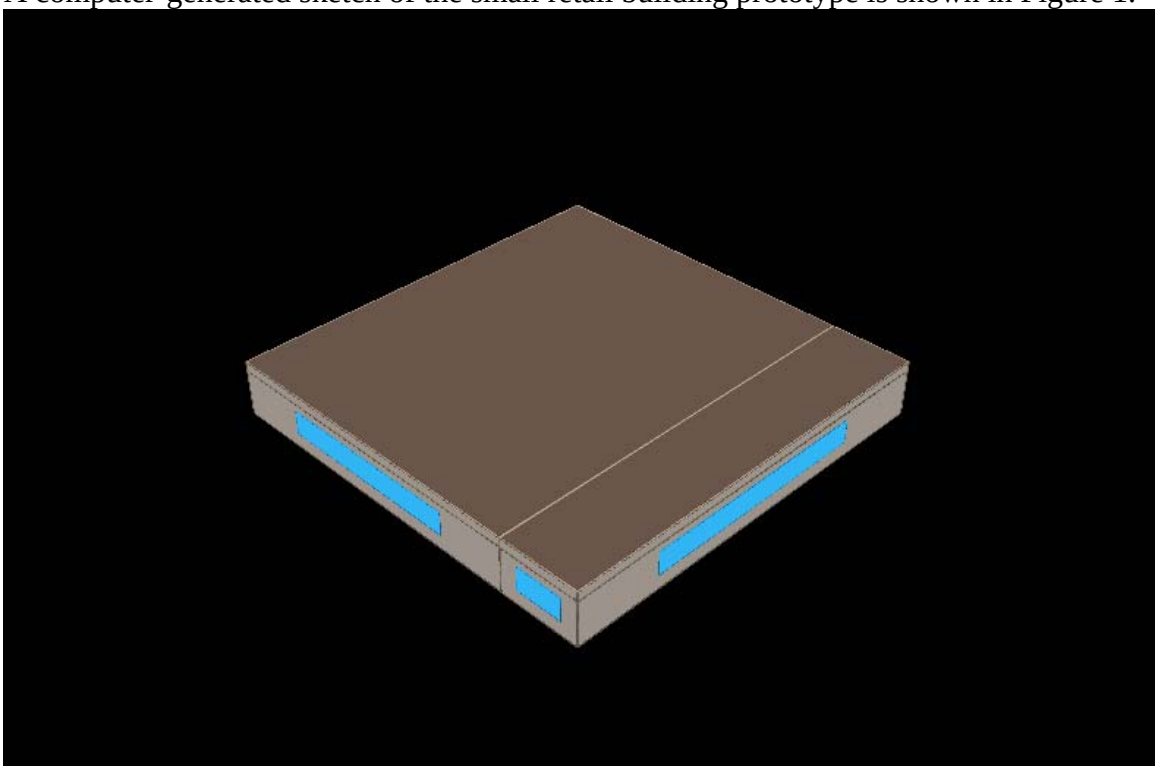


Figure 1. Small Retail Prototype Building Rendering

Full-Service Restaurant

A prototypical building energy simulation model for a full-service restaurant was developed using the DOE-2.2 building energy simulation program. The characteristics of the full service restaurant prototype are summarized in Table 7.

Table 7. Full Service Restaurant Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square foot dining area 600 square foot entry/reception area 1200 square foot kitchen 200 square foot restrooms
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Dining area: 1.7 W/SF Entry area: 2.5 W/SF Kitchen: 4.3 W/SF Restrooms: 1.0 W/SF
Plug load density	Dining area: 0.6 W/SF Entry area: 0.6 W/SF Kitchen: 3.1 W/SF Restrooms: 0.2 W/SF
Operating hours	9am – 12am
HVAC system type	Packaged single zone, no economizer
HVAC system size	140 – 160 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 82 cooling, 67 heating

A computer-generated sketch of the full-service restaurant prototype is shown in Figure 2.

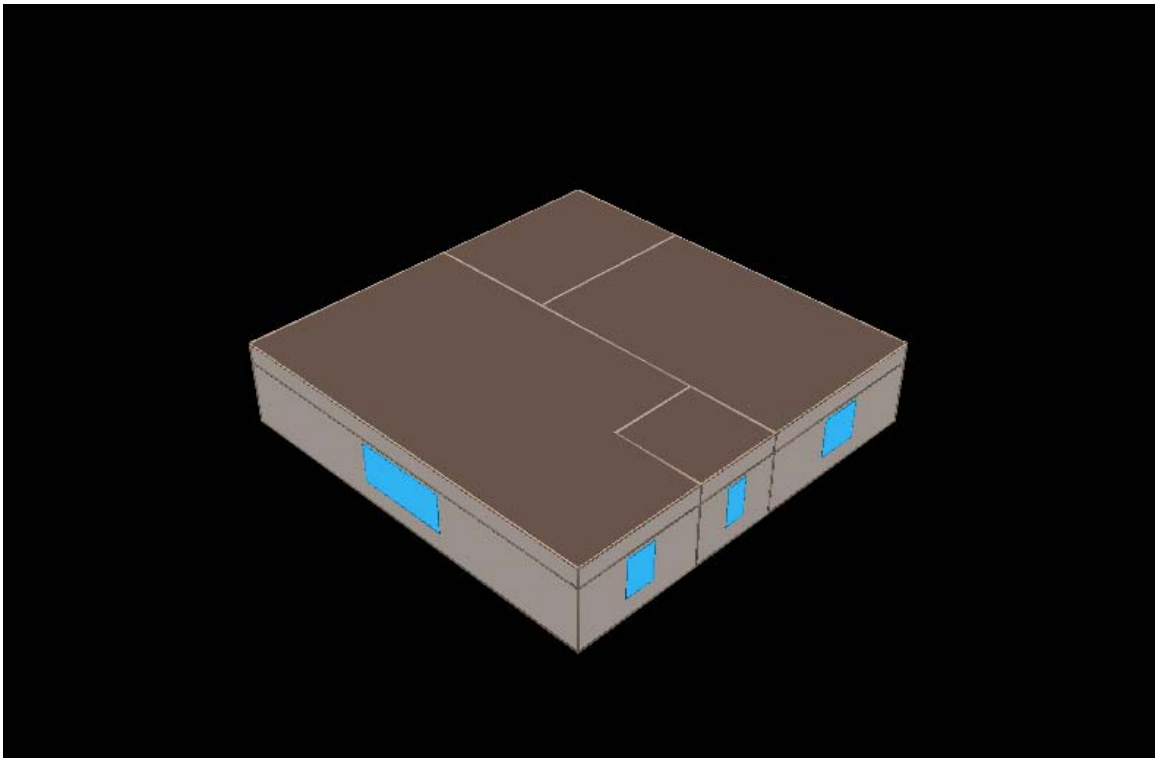


Figure 2. Full Service Restaurant Prototype Rendering

Small Office

A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The characteristics of the small office prototype are summarized in Table 8.

Table 8. Small Office Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Perimeter offices: 2.2 W/SF Core offices: 1.5 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 245 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the small office prototype is shown in Figure 3.

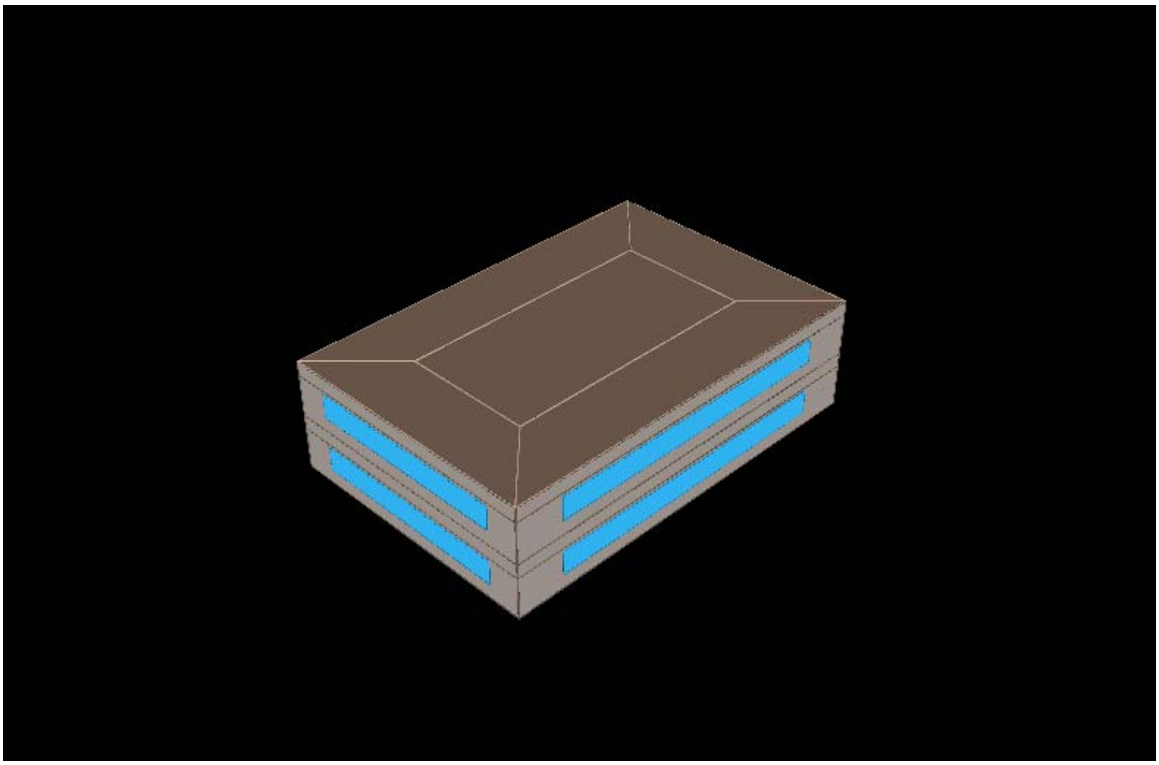


Figure 3. Small Office Prototype Building Rendering

Light Industrial

A prototypical building energy simulation model for a light industrial building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 9.

Table 9. Light Industrial Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total 80,000 SF factory 20,000 SF warehouse
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Factory – 2.1 W/SF Warehouse – 0.9 W/SF
Plug load density	Factory – 1.2 W/SF Warehouse – 0.2 W/SF
Operating hours	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	500 - 560 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 78 cooling, 70 heating Unoccupied hours: 83 cooling, 65 heating

A computer-generated sketch of the prototype is shown in Figure 4.

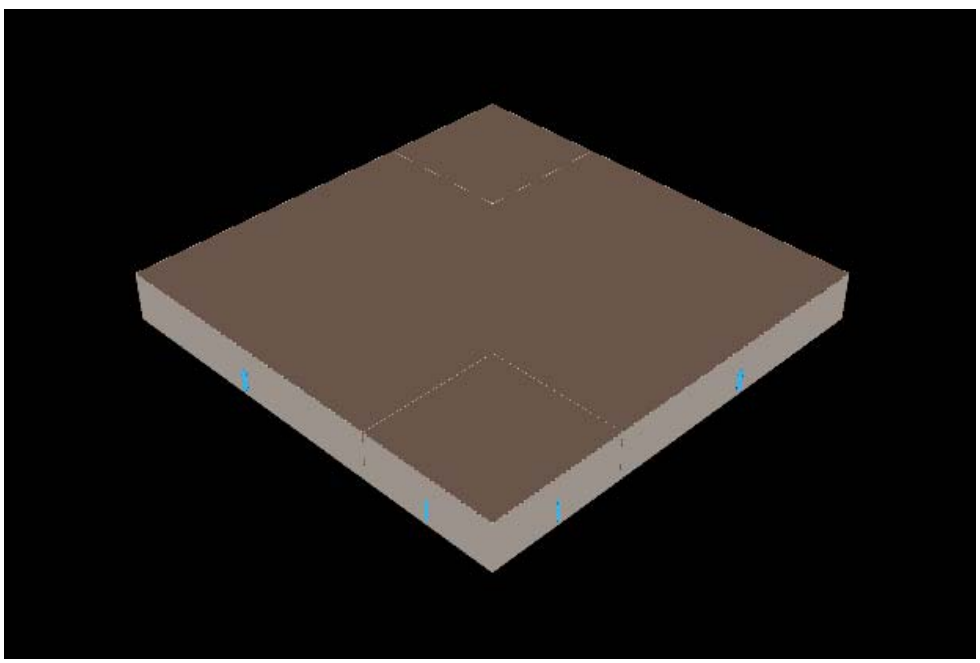


Figure 4. Light Industrial Building Rendering

Big Box Retail

A prototypical building energy simulation model for a big box retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 10.

Table 10. Big Box Retail Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 SF Storage: 11,870 SF Office: 4,683 SF Auto repair: 5,151 SF Kitchen: 1,459 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Storage: 0.88 W/SF Office: 2.2 W/SF Auto repair: 2.15 W/SF Kitchen: 4.3 W/SF
Plug load density	Sales: 1.15 W/SF Storage: 0.23 W/SF Office: 1.73 W/SF Auto repair: 1.15 W/SF Kitchen: 3.23 W/SF
Operating hours	Mon-Sun: 10am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 260 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown in Figure 5.

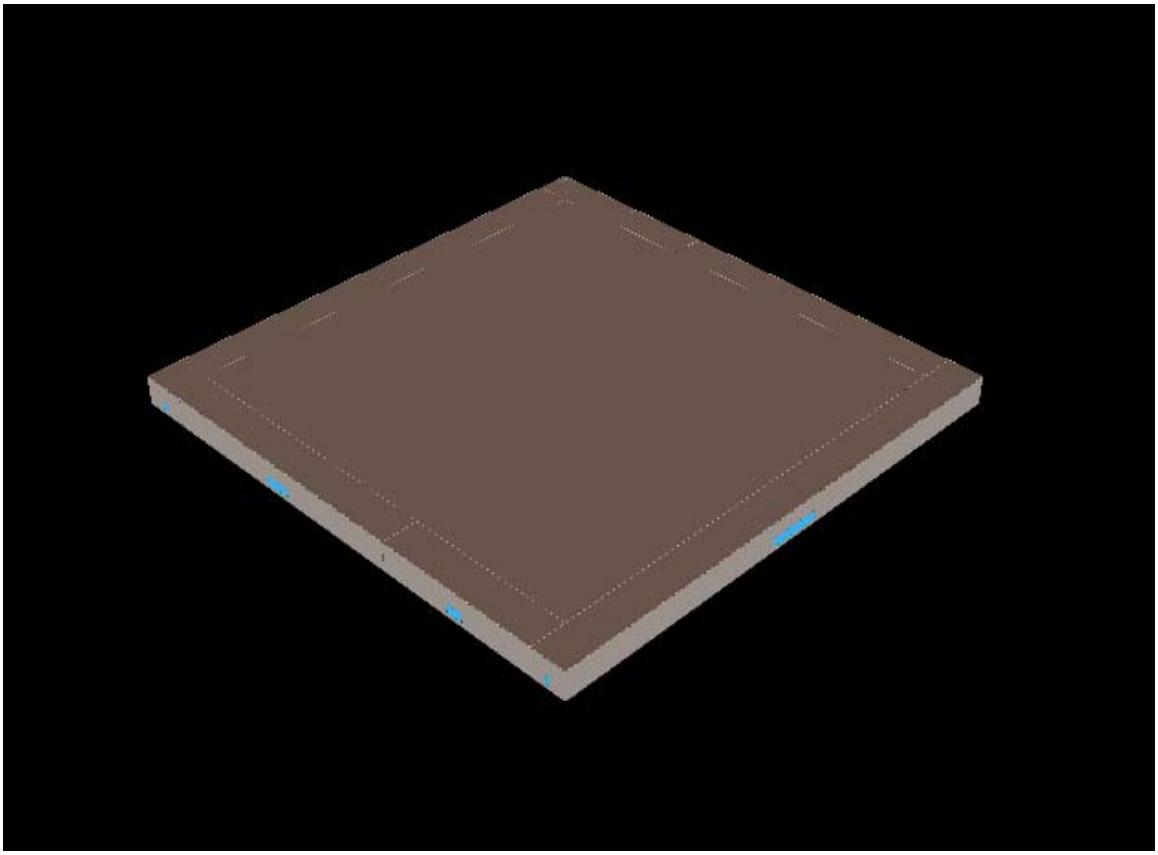


Figure 5. Big Box Retail Building Rendering

Fast Food Restaurant

A prototypical building energy simulation model for a fast food restaurant was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 11.

Table 11. Fast Food Restaurant Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square feet 1000 SF dining 600 SF entry/lobby 300 SF kitchen 100 SF restroom
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	1.7 W/SF dining 2.5 W/SF entry/lobby 4.3 W/SF kitchen 1.0 W/SF restroom
Plug load density	0.6 W/SF dining 0.6 W/SF entry/lobby 4.3 W/SF kitchen 0.2 W/SF restroom
Operating hours	Mon-Sun: 6am – 11pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 – 120 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 82 cooling, 67 heating

A computer-generated sketch of the prototype is shown in Figure 6.

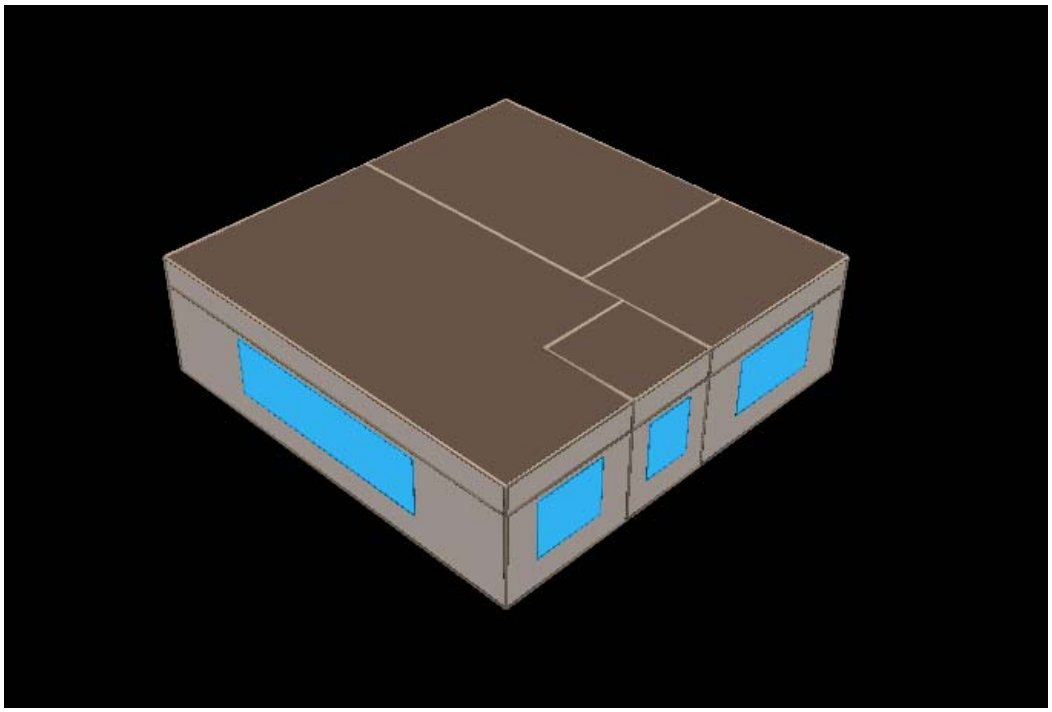


Figure 6. Fast Food Restaurant Building Rendering

School

A prototypical building energy simulation model for an elementary school was developed using the DOE-2.2 building energy simulation program. The model is really of two identical buildings oriented in two different directions. The characteristics of the prototype are summarized in Table 12.

Table 12. Elementary School Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 15,750 SF Cafeteria: 3,750 SF Gymnasium: 3,750 SF Kitchen: 1,750 SF
Number of floors	1
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Classroom: 4.4 W/SF Cafeteria: 1.7 W/SF Gymnasium: 2.1 W/SF Kitchen: 4.3 W/SF
Plug load density	Classroom: 1.2 W/SF Cafeteria: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 4.2 W/SF
Operating hours	Mon-Fri: 8am – 6pm Sun: 8am – 4pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	160 - 180 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown in Figure 7.

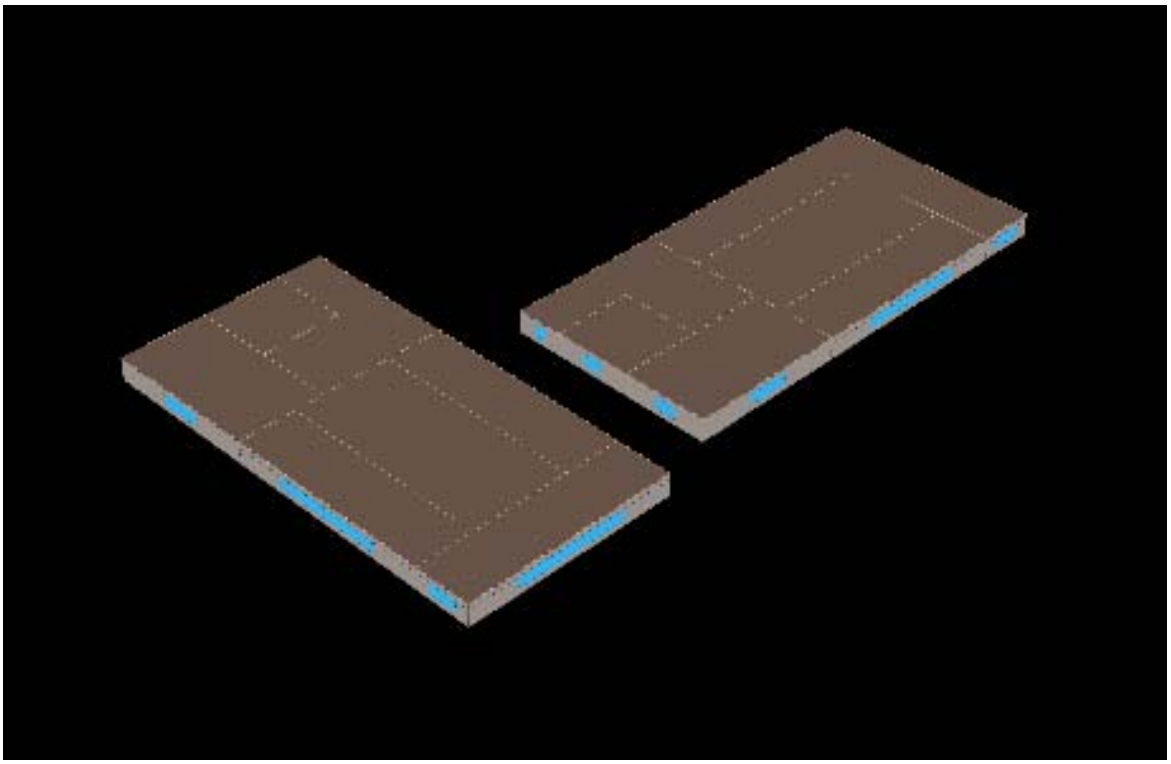


Figure 7. School Building Rendering

Assembly

A prototypical building energy simulation model for an assembly building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 13.

Table 13. Assembly Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 SF Office: 760 SF
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Auditorium: 3.4 W/SF Office: 2.2 W/SF
Plug load density	Auditorium: 1.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sun: 8am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 - 110 SF/ton depending on climate
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown in Figure 8.

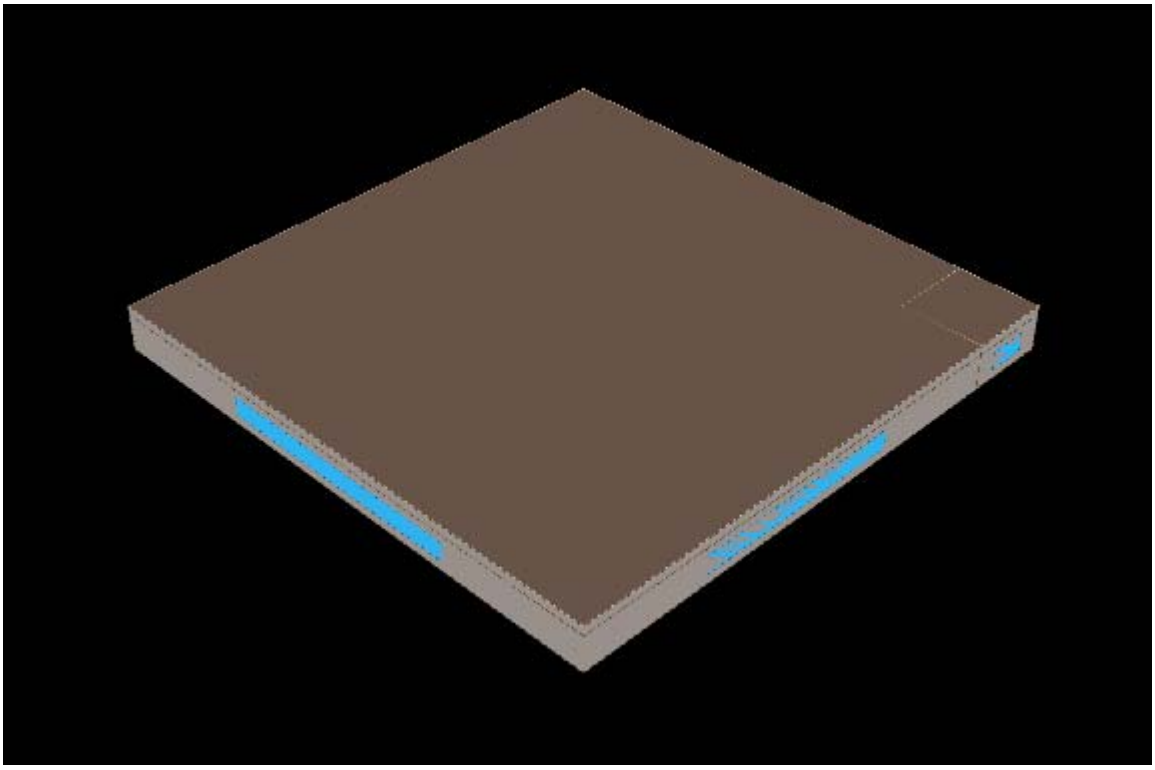


Figure 8. Assembly Building Rendering

Grocery

A prototypical building energy simulation model for a grocery building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 14.

Table 14. Grocery Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	50,000 square feet Sales: 40,000 SF Office and employee lounge: 3,500 SF Dry storage: 2,860 SF 50 °F prep area: 1,268 SF 35 °F walk-in cooler: 1,560 SF - 5 °F walk-in freezer: 812 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Office: 2.2 W/SF Storage: 1.82 W/SF

Characteristic	Value
	50°F prep area: 4.3 W/SF 35°F walk-in cooler: 0.9 W/SF - 5°F walk-in freezer: 0.9 W/SF
Equipment power density	Sales: 1.15 W/SF Office: 1.73 W/SF Storage: 0.23 W/SF 50°F prep area: 0.23 W/SF + 36 kBtu/hr process load 35°F walk-in cooler: 0.23 W/SF + 17 kBtu/hr process load - 5°F walk-in freezer: 0.23 W/SF+ 29 kBtu/hr process load
Operating hours	Mon-Sun: 6am – 10pm
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	Low temperature (-20°F suction temp): 23 compressor ton Medium temperature (18°F suction temp): 45 compressor ton
Refrigeration condenser size	Low temperature: 535 kBtu/hr THR Medium temperature: 756 kBtu/hr THR
Thermostat setpoints	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown in Figure 9.

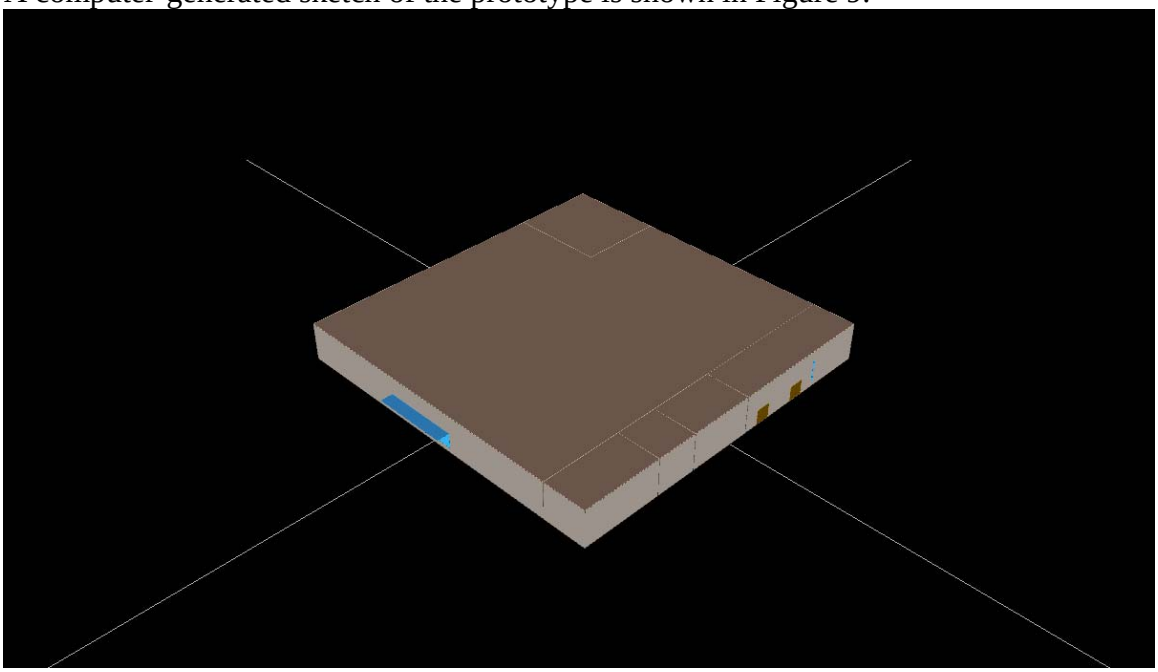


Figure 9. Grocery Building Rendering